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Noh et al.

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(45) **Date of Patent: Aug. 16, 2016**

(54) **METHOD AND DEVICE FOR TRANSMITTING AN UPLINK CONTROL SIGNAL IN A WIRELESS COMMUNICATION SYSTEM**

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(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 255 days.

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(86) PCT No.: **PCT/KR2011/005510**

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(2), (4) Date: **Jan. 24, 2013**

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PCT Pub. Date: **Feb. 2, 2012**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04W 4/00 (2009.01)
H04W 72/04 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 72/0413*** (2013.01); ***H04L 1/0031*** (2013.01); ***H04L 5/001*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . H04L 1/0031; H04L 1/1671; H04L 27/2633; H04L 27/2636; H04L 5/001; H04L 5/0023; H04L 5/0048; H04L 5/0053; H04L 5/0057; H04L 5/0066; H04L 5/0098; H04W 72/0413; H04W 72/085
See application file for complete search history.

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(Continued)

Primary Examiner — Chi H Pham
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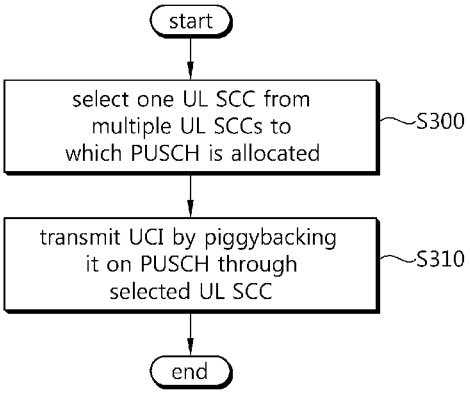
(57) **ABSTRACT**

Provided are a method and a device for transmitting an uplink control signal in a wireless communication system. User equipment selects uplink (UL) secondary component carrier (SCC) from a plurality of physical uplink shared channel (PUSCH)-scheduled UL SCCs in a carrier aggregation (CA) system including a plurality of UL component carriers (CCs), and transmits uplink control information (UCI) by piggybacking it on the PUSCH scheduled for the selected single UL SCC. Herein, the PUSCH is not scheduled for a primary CC (PCC) of the CA system.

12 Claims, 23 Drawing Sheets



(51) **Int. Cl.**

H04L 5/00	(2006.01)
H04L 27/26	(2006.01)
H04W 72/08	(2009.01)
H04L 1/00	(2006.01)
H04L 1/16	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 5/0053*** (2013.01); ***H04L 5/0066*** (2013.01); ***H04L 5/0098*** (2013.01); ***H04L 27/2633*** (2013.01); ***H04L 27/2636*** (2013.01); ***H04W 72/085*** (2013.01); *H04L 1/1671* (2013.01); *H04L 5/0023* (2013.01); *H04L 5/0048* (2013.01); *H04L 5/0057* (2013.01)

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* cited by examiner

FIG. 1

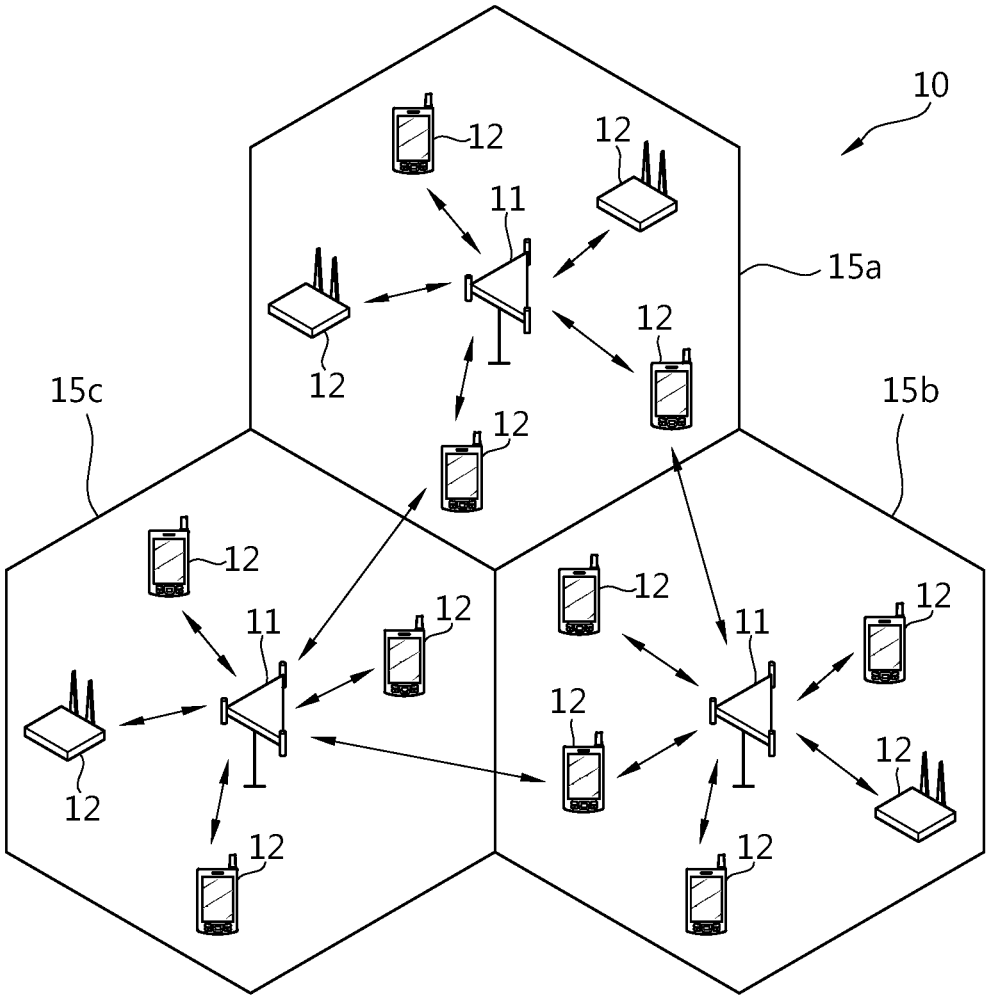


FIG. 2

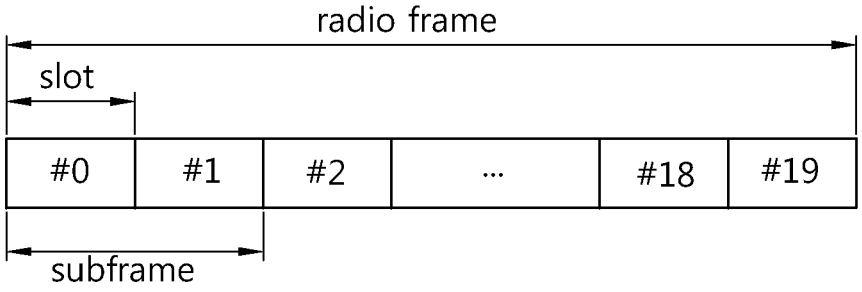


FIG. 3

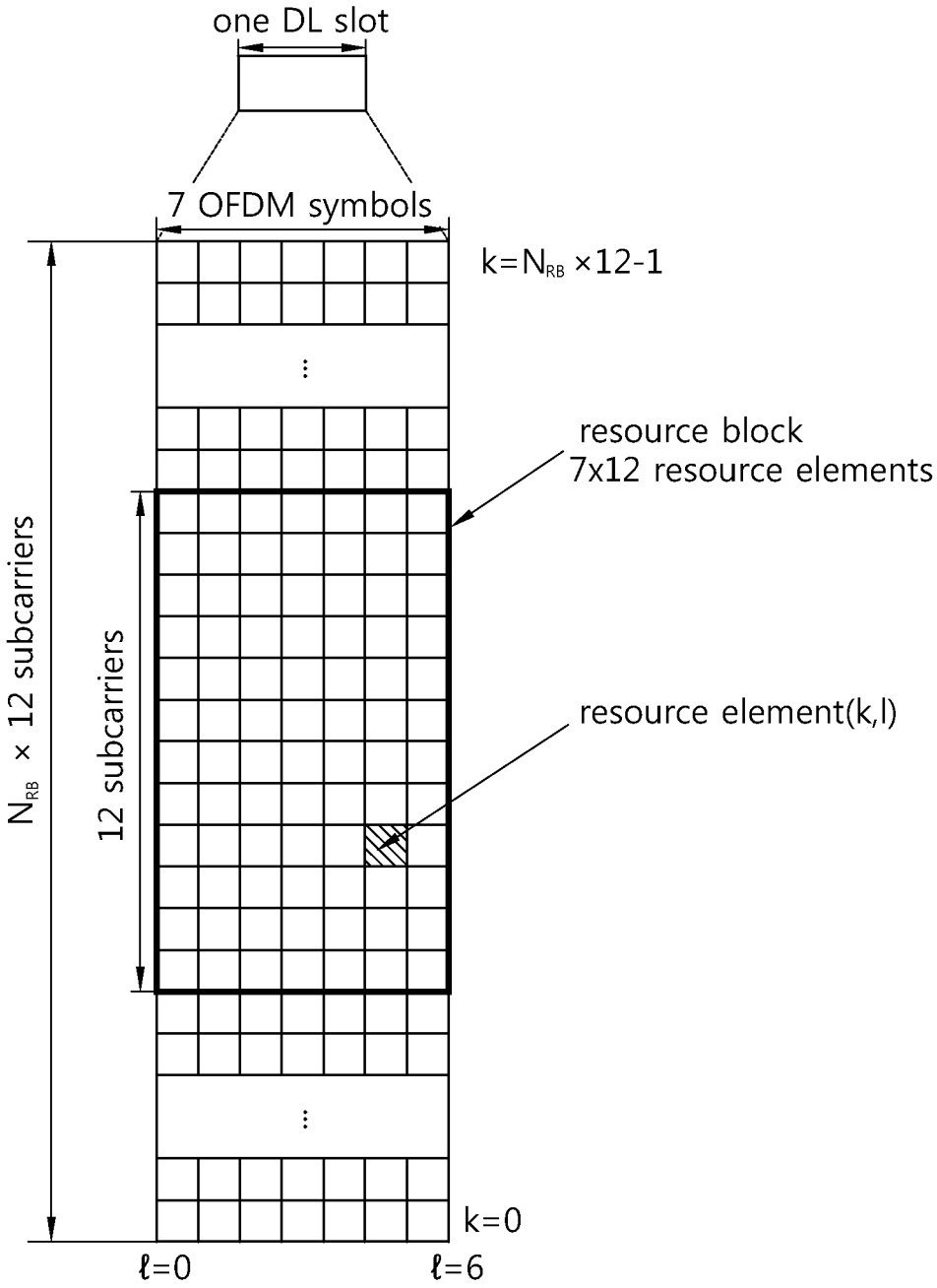

one DL slot
7 OFDM symbols
k=N_RB ×12-1
resource block
7x12 resource elements
resource element(k,l)
N_RB × 12 subcarriers
12 subcarriers
k=0
ℓ=0
ℓ=6

FIG. 4

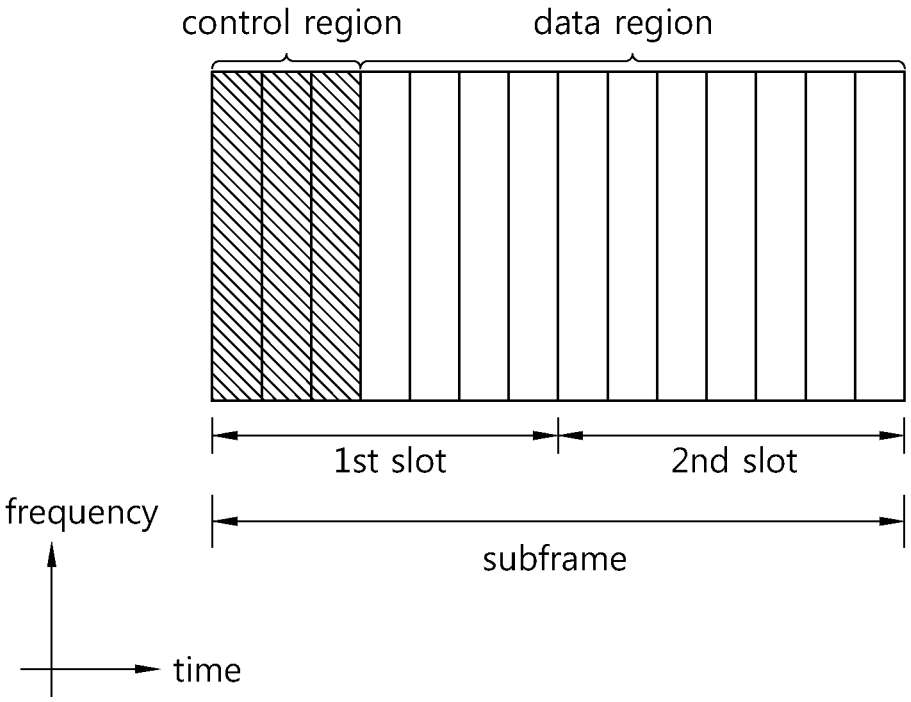

control region
data region
1st slot
2nd slot
frequency
subframe
time

FIG. 5

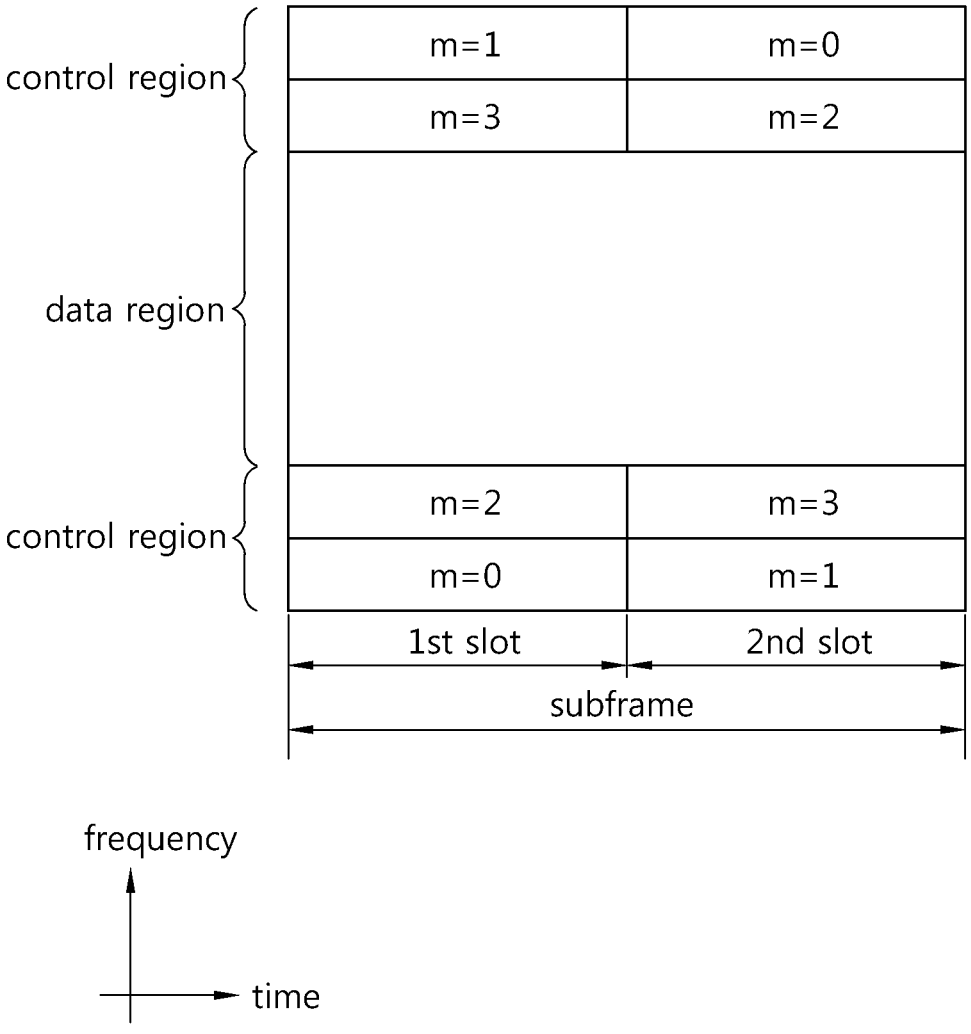

control region
m=1
m=0
m=3
m=2
data region
control region
m=2
m=3
m=0
m=1
1st slot
2nd slot
subframe
frequency
time

FIG. 6

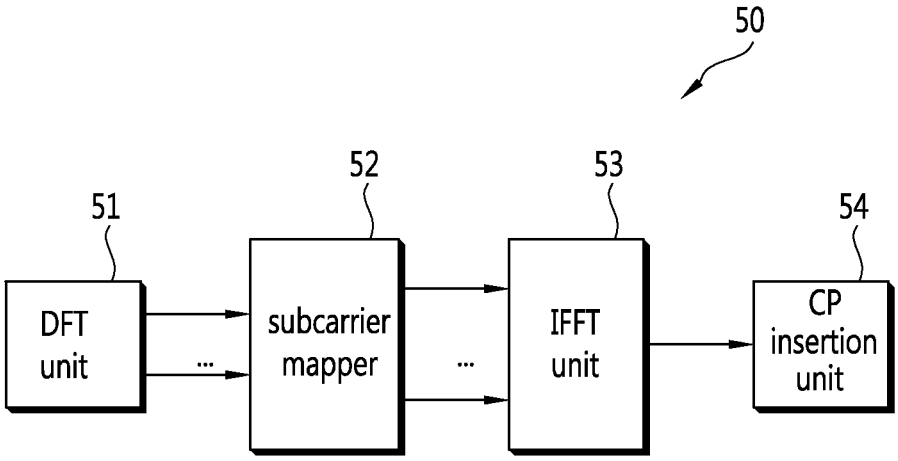
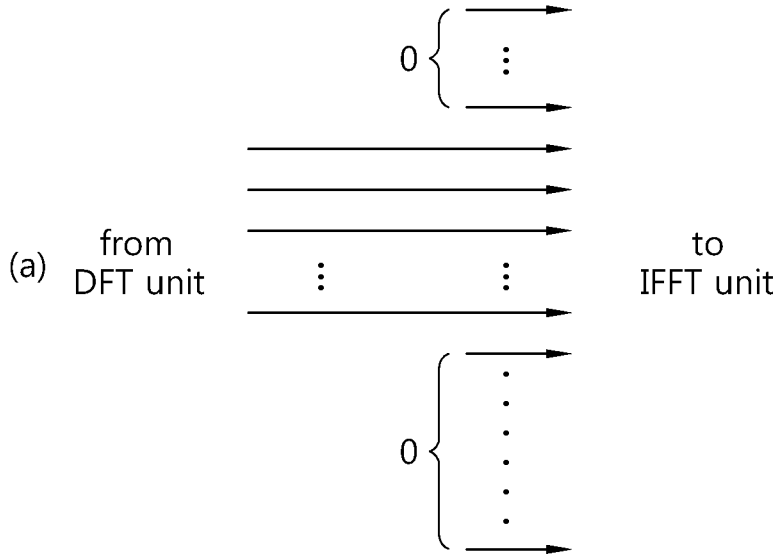

50
51
52
53
54
DFT unit
subcarrier mapper
IFFT unit
CP insertion unit

FIG. 7


0
(a)
from
DFT unit
to
IFFT unit
0

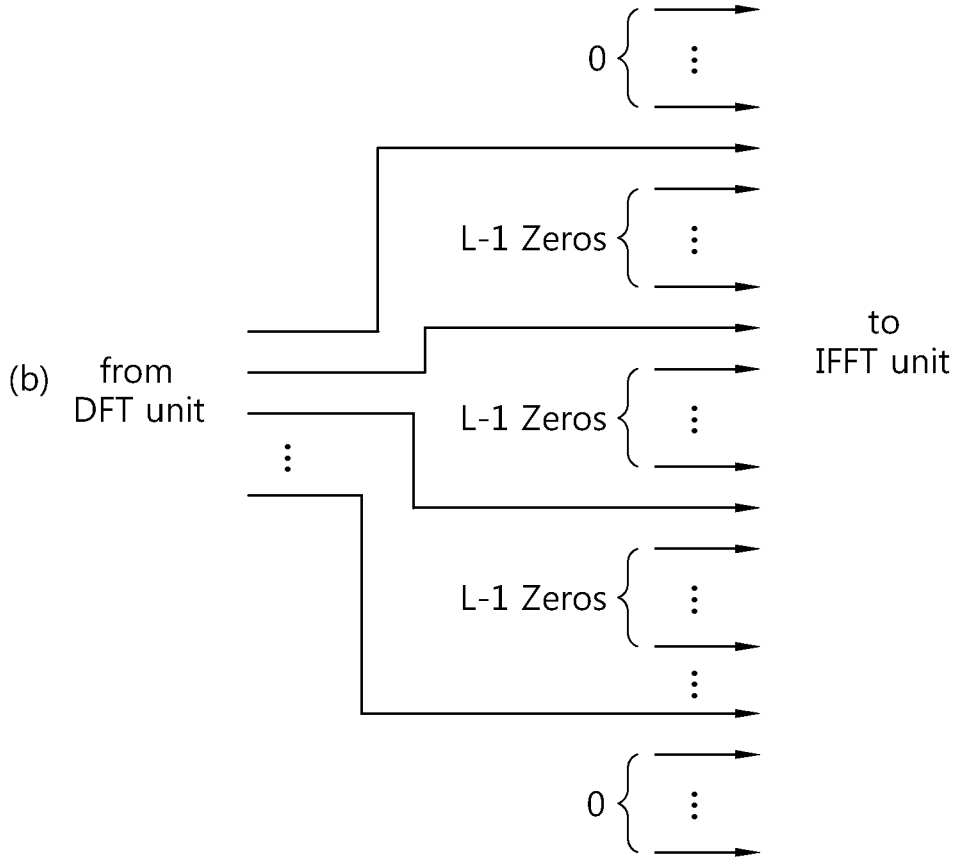

0
L-1 Zeros
(b)
from
DFT unit
to
IFFT unit
L-1 Zeros
L-1 Zeros
0

FIG. 8

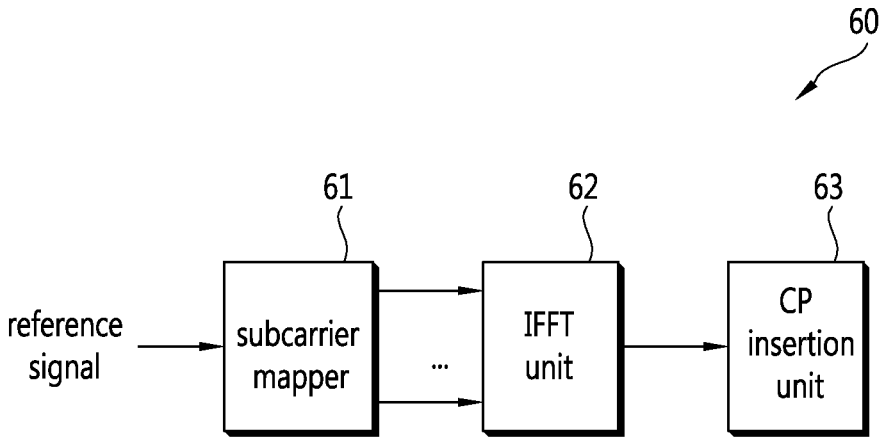

60
61
62
63
reference signal
subcarrier mapper
...
IFFT unit
CP insertion unit

FIG. 9

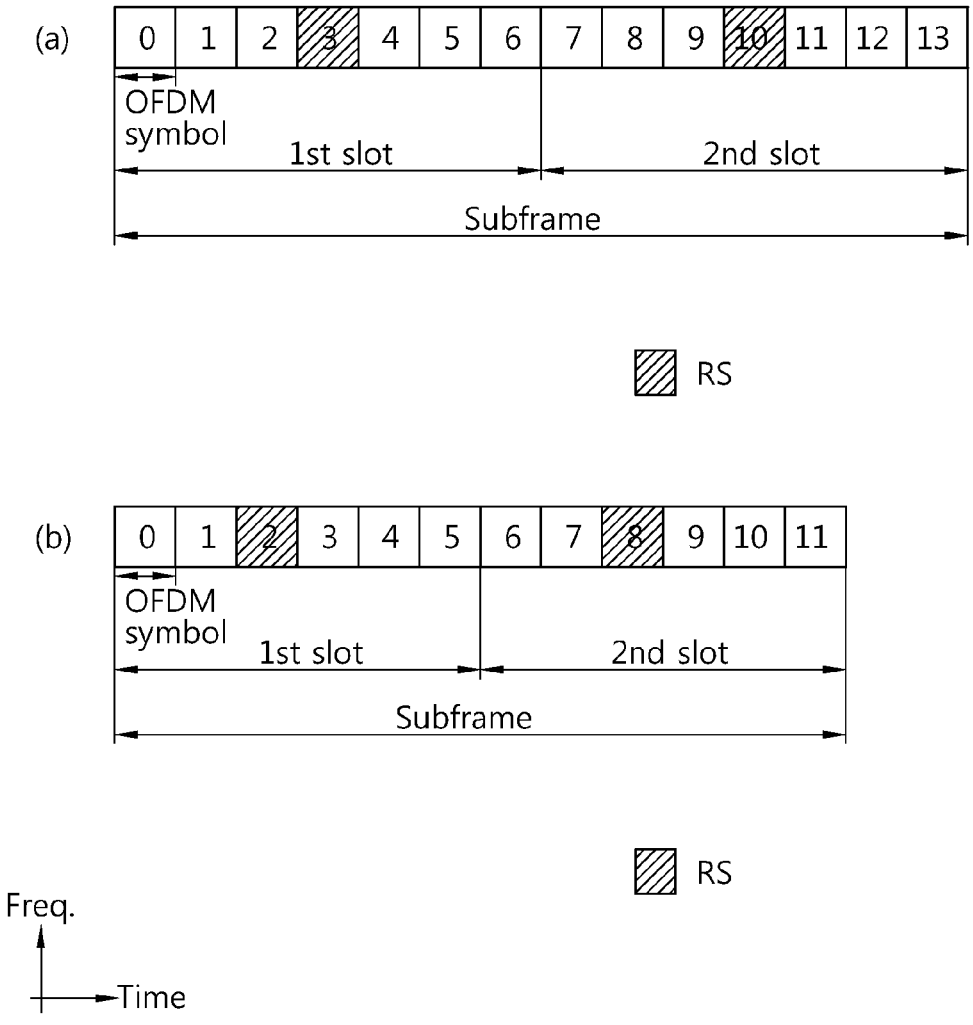

(a)
0 1 2 3 4 5 6 7 8 9 10 11 12 13
OFDM symbol
1st slot
2nd slot
Subframe
RS
(b)
0 1 2 3 4 5 6 7 8 9 10 11
OFDM symbol
1st slot
2nd slot
Subframe
RS
Freq.
Time

FIG. 10

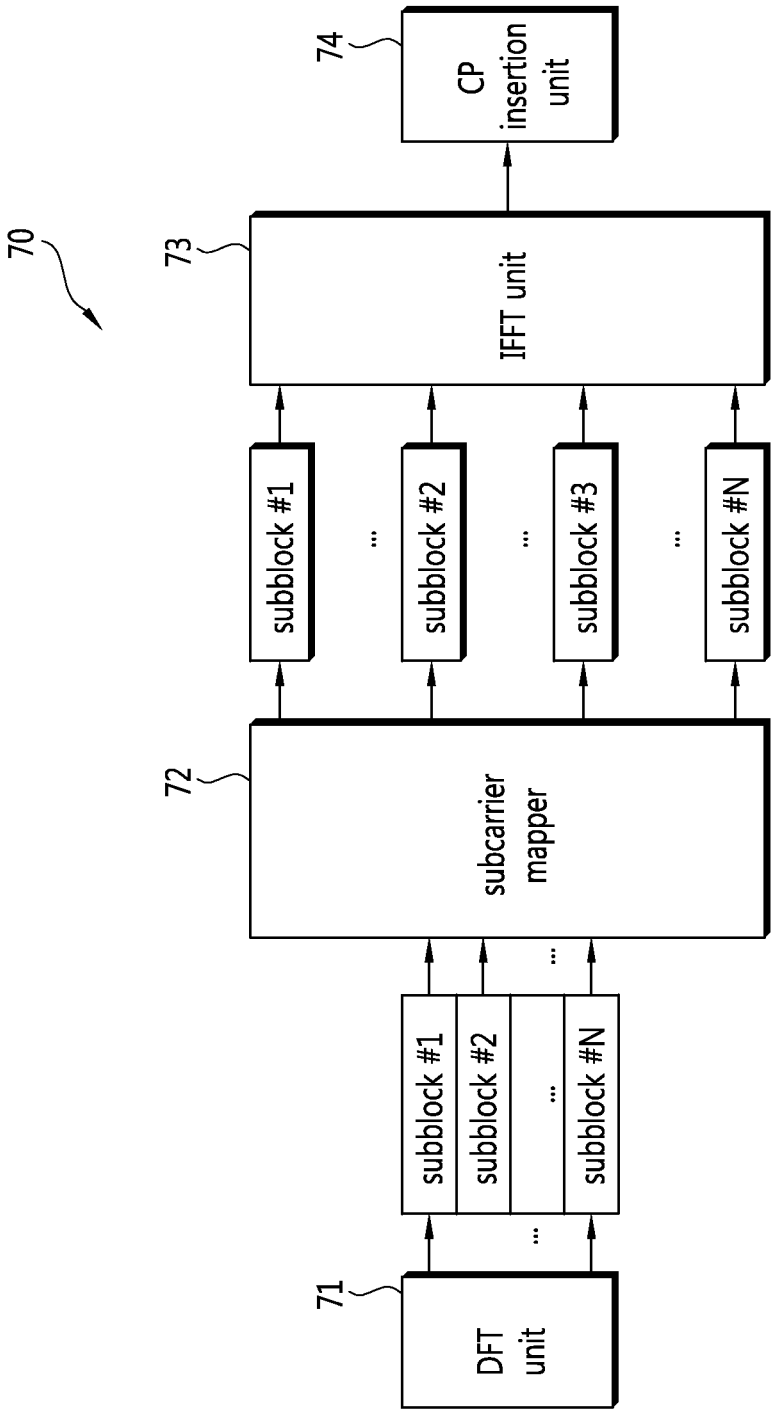

70
71
DFT unit
72
subcarrier mapper
73
IFFT unit
74
CP insertion unit
subblock #1
subblock #2
subblock #3
subblock #N
subblock #1
subblock #2
subblock #N

FIG. 11

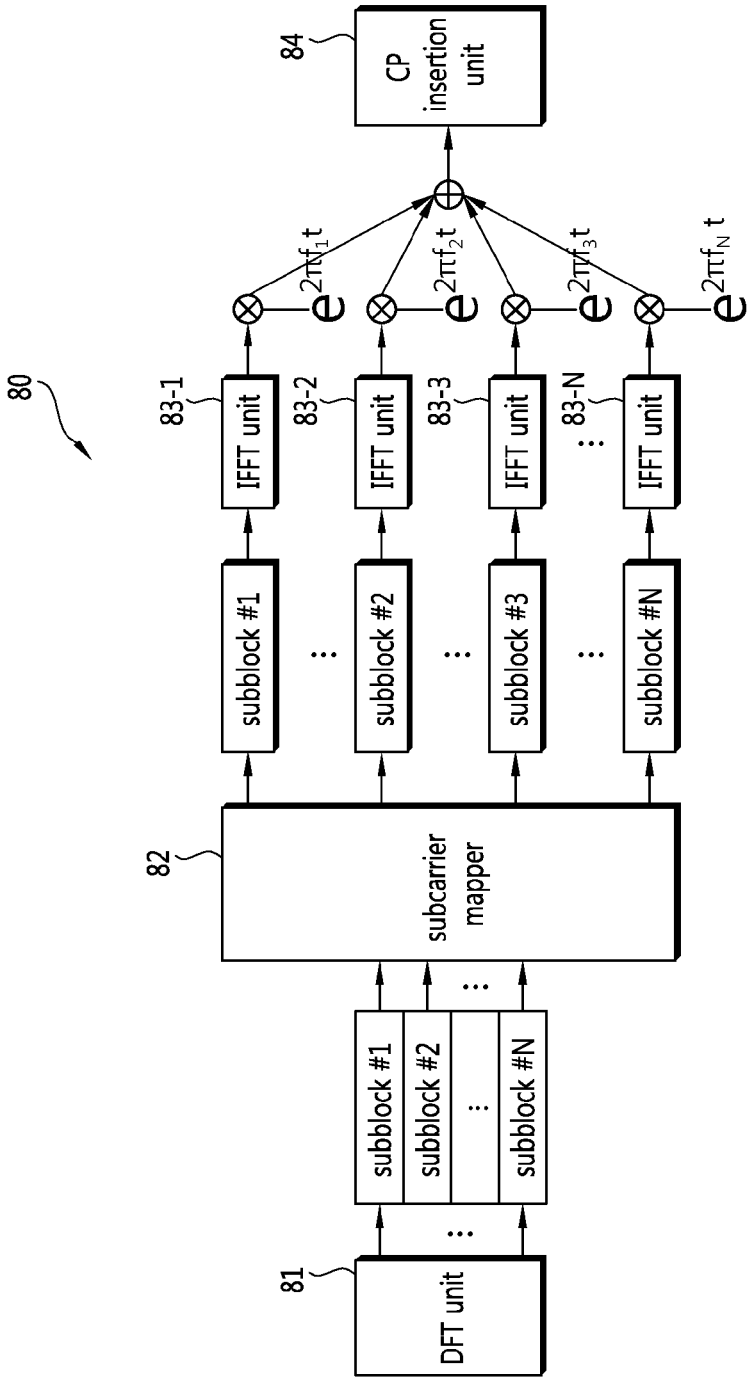

80
81
DFT unit
82
subcarrier mapper
83-1
83-2
83-3
83-N
IFFT unit
subblock #1
subblock #2
subblock #3
subblock #N
84
CP insertion unit
$e^{2\pi f_1 t}$
$e^{2\pi f_2 t}$
$e^{2\pi f_3 t}$
$e^{2\pi f_N t}$

FIG. 12

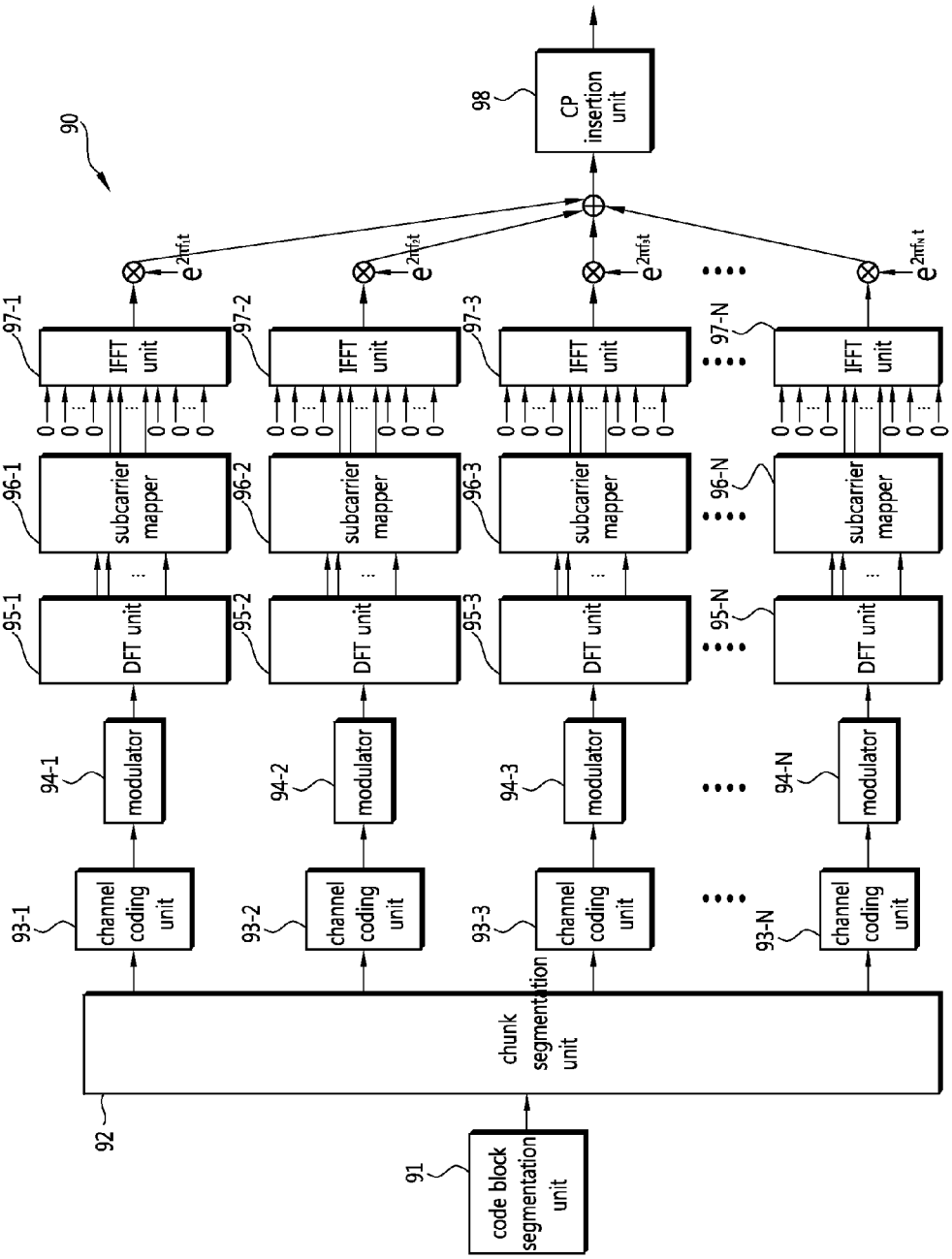

90
91
code block segmentation unit
92
chunk segmentation unit
93-1
93-2
93-3
93-N
channel coding unit
94-1
94-2
94-3
94-N
modulator
95-1
95-2
95-3
95-N
DFT unit
96-1
96-2
96-3
96-N
subcarrier mapper
97-1
97-2
97-3
97-N
IFFT unit
98
CP insertion unit

FIG. 13

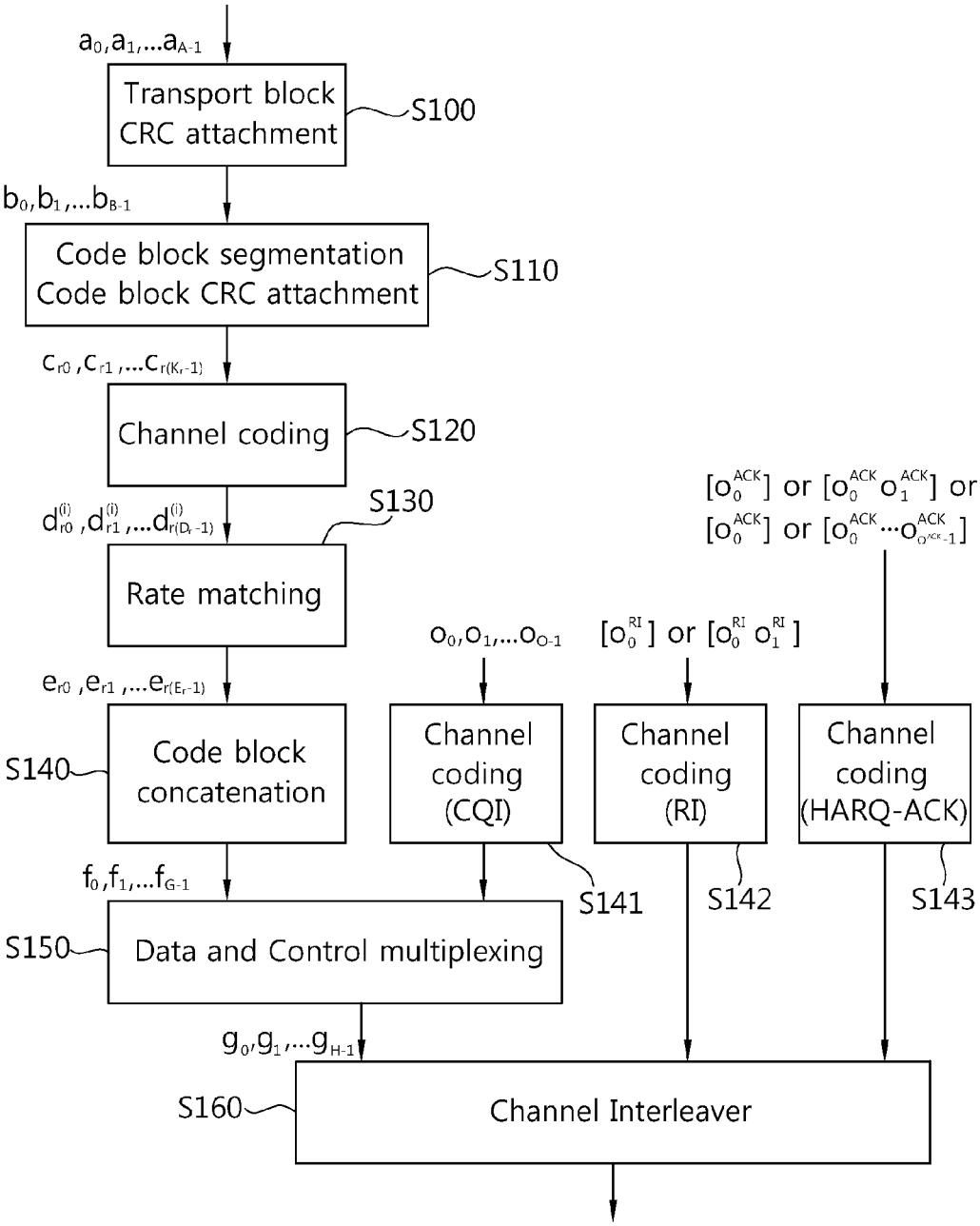

$a_0, a_1, \ldots a_{A-1}$
Transport block CRC attachment
S100
$b_0, b_1, \ldots b_{B-1}$
Code block segmentation Code block CRC attachment
S110
$c_{r0}, c_{r1}, \ldots c_{r(K_r-1)}$
Channel coding
S120
$d_{r0}^{(i)}, d_{r1}^{(i)}, \ldots d_{r(D_r-1)}^{(i)}$
S130
Rate matching
$e_{r0}, e_{r1}, \ldots e_{r(E_r-1)}$
S140
Code block concatenation
$o_0, o_1, \ldots o_{O-1}$
Channel coding (CQI)
$[o_0^{RI}]$ or $[o_0^{RI}\ o_1^{RI}]$
Channel coding (RI)
$[o_0^{ACK}]$ or $[o_0^{ACK}\ o_1^{ACK}]$ or $[o_0^{ACK}]$ or $[o_0^{ACK} \cdots o_{O^{ACK}-1}^{ACK}]$
Channel coding (HARQ-ACK)
S141
S142
S143
$f_0, f_1, \ldots f_{G-1}$
S150
Data and Control multiplexing
$g_0, g_1, \ldots g_{H-1}$
S160
Channel Interleaver

FIG. 14

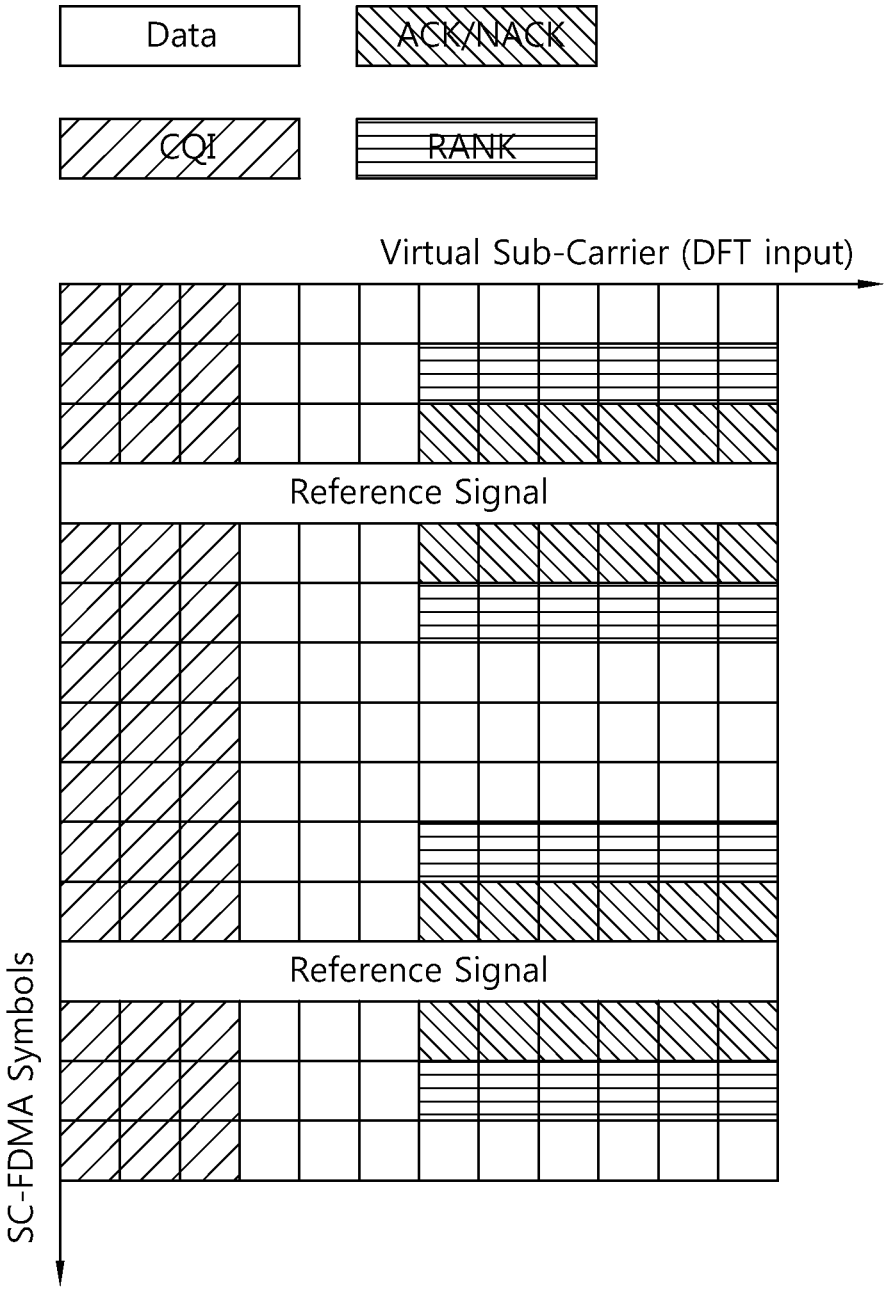

Data
ACK/NACK
CQI
RANK
Virtual Sub-Carrier (DFT input)
Reference Signal
Reference Signal
SC-FDMA Symbols

FIG. 15

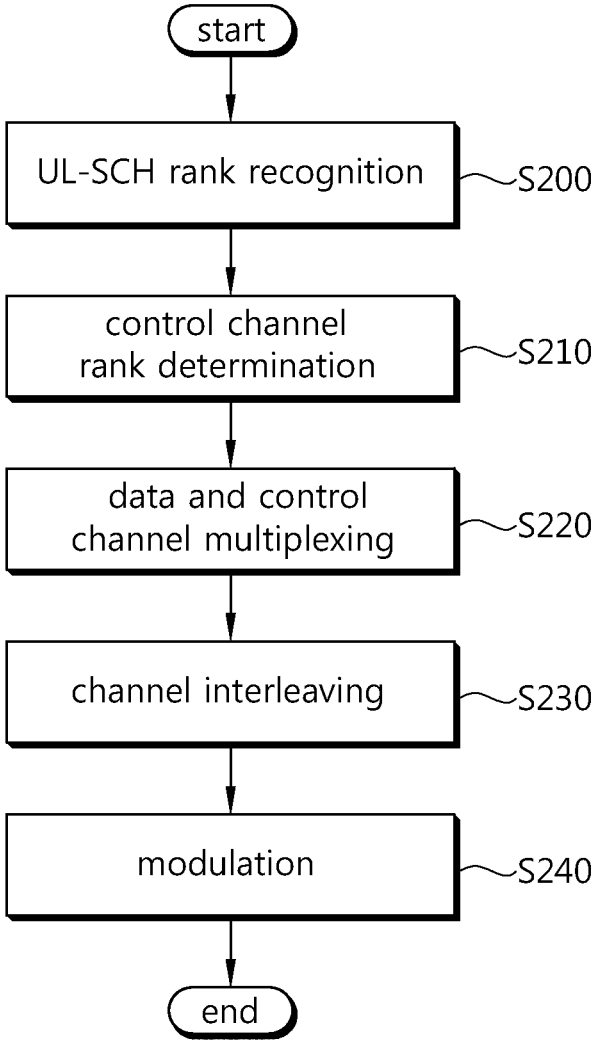

start
UL-SCH rank recognition
S200
control channel rank determination
S210
data and control channel multiplexing
S220
channel interleaving
S230
modulation
S240
end

FIG. 16

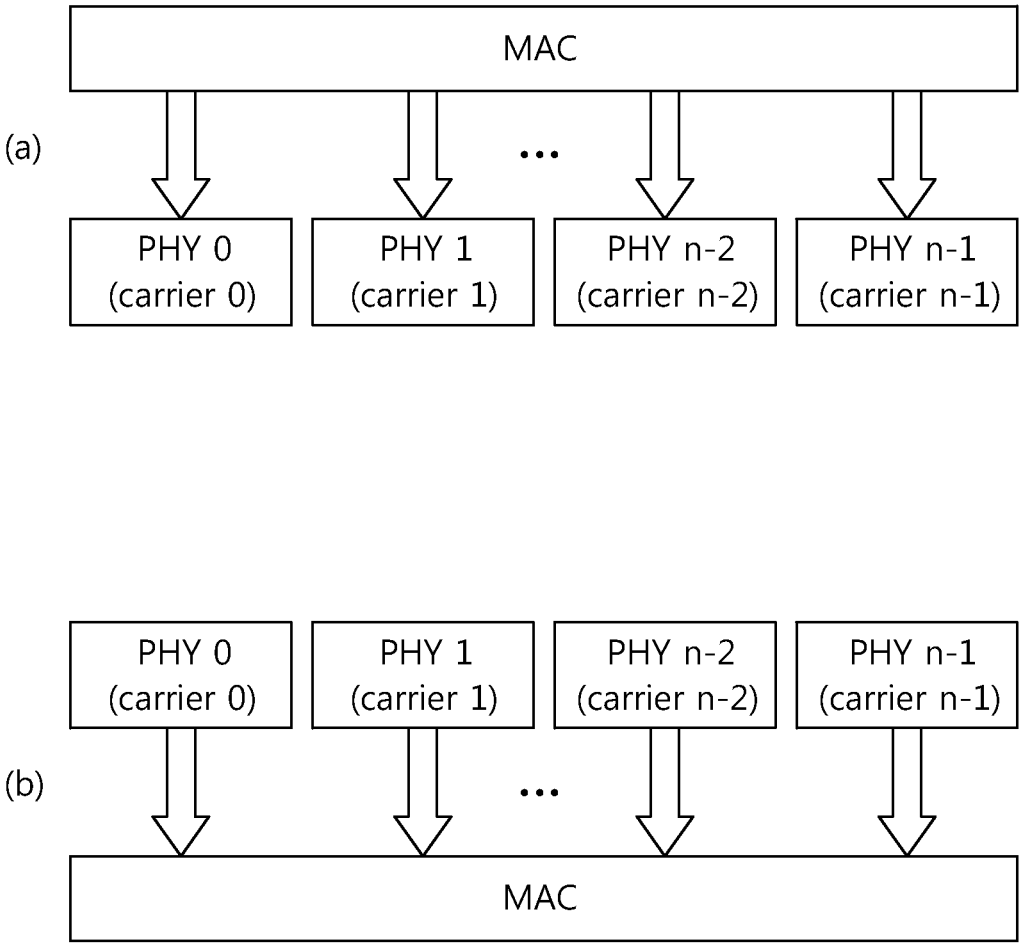

(a)
MAC
PHY 0 (carrier 0)
PHY 1 (carrier 1)
PHY n-2 (carrier n-2)
PHY n-1 (carrier n-1)
(b)
PHY 0 (carrier 0)
PHY 1 (carrier 1)
PHY n-2 (carrier n-2)
PHY n-1 (carrier n-1)
MAC

FIG. 17

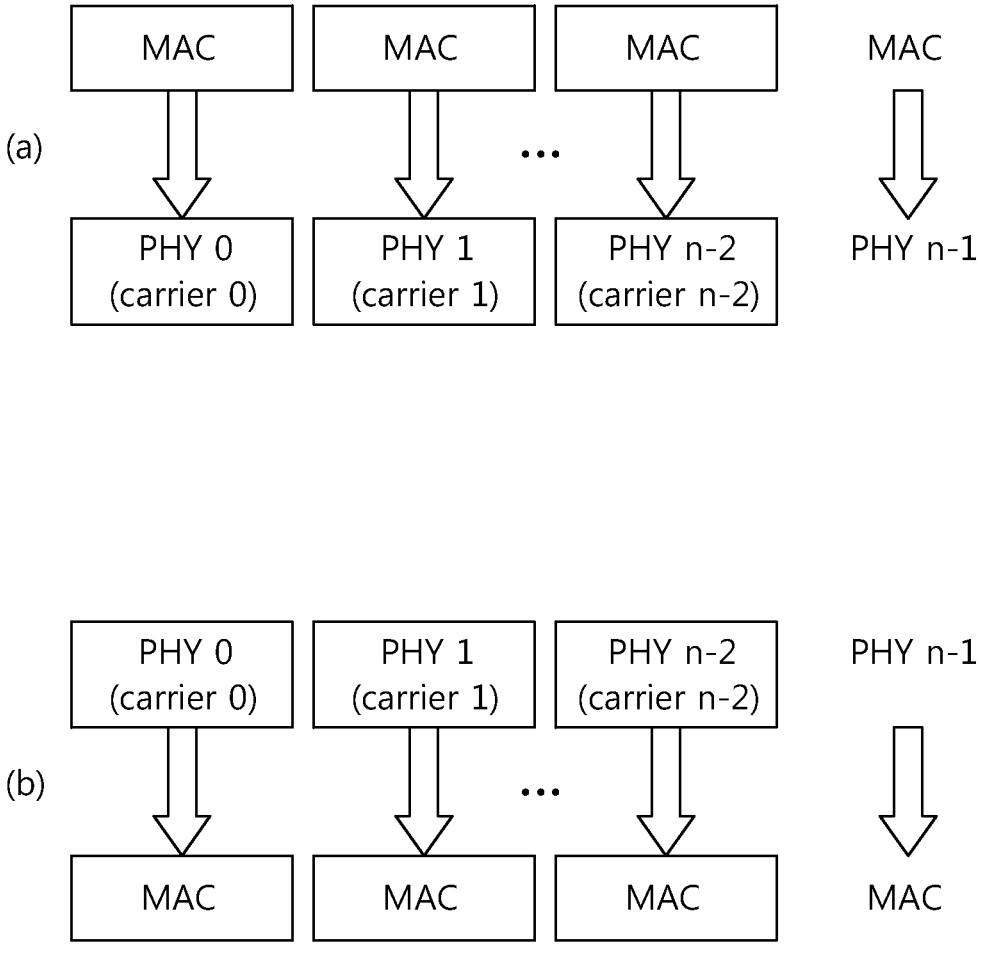
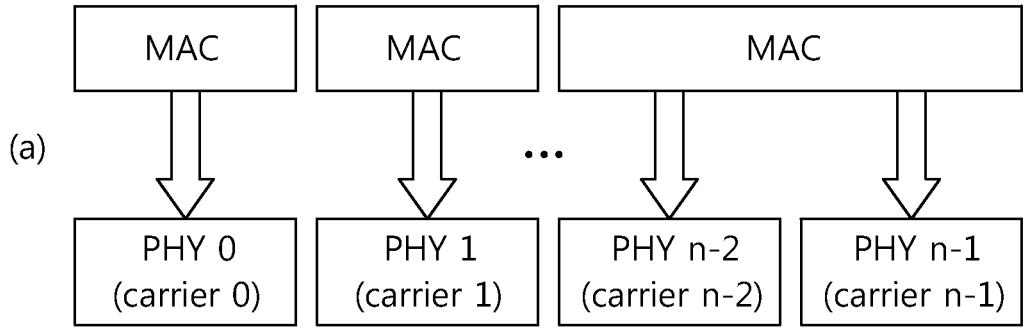

(a)
MAC
MAC
MAC
MAC
PHY 0
(carrier 0)
PHY 1
(carrier 1)
PHY n-2
(carrier n-2)
PHY n-1
(b)
PHY 0
(carrier 0)
PHY 1
(carrier 1)
PHY n-2
(carrier n-2)
PHY n-1
MAC
MAC
MAC
MAC

FIG. 18


(a)
MAC
MAC
MAC
PHY 0
(carrier 0)
PHY 1
(carrier 1)
PHY n-2
(carrier n-2)
PHY n-1
(carrier n-1)

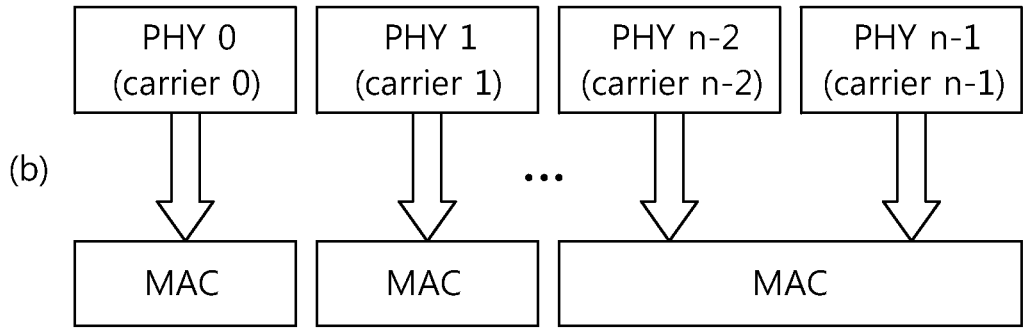

(b)
PHY 0
(carrier 0)
PHY 1
(carrier 1)
PHY n-2
(carrier n-2)
PHY n-1
(carrier n-1)
MAC
MAC
MAC

FIG. 19

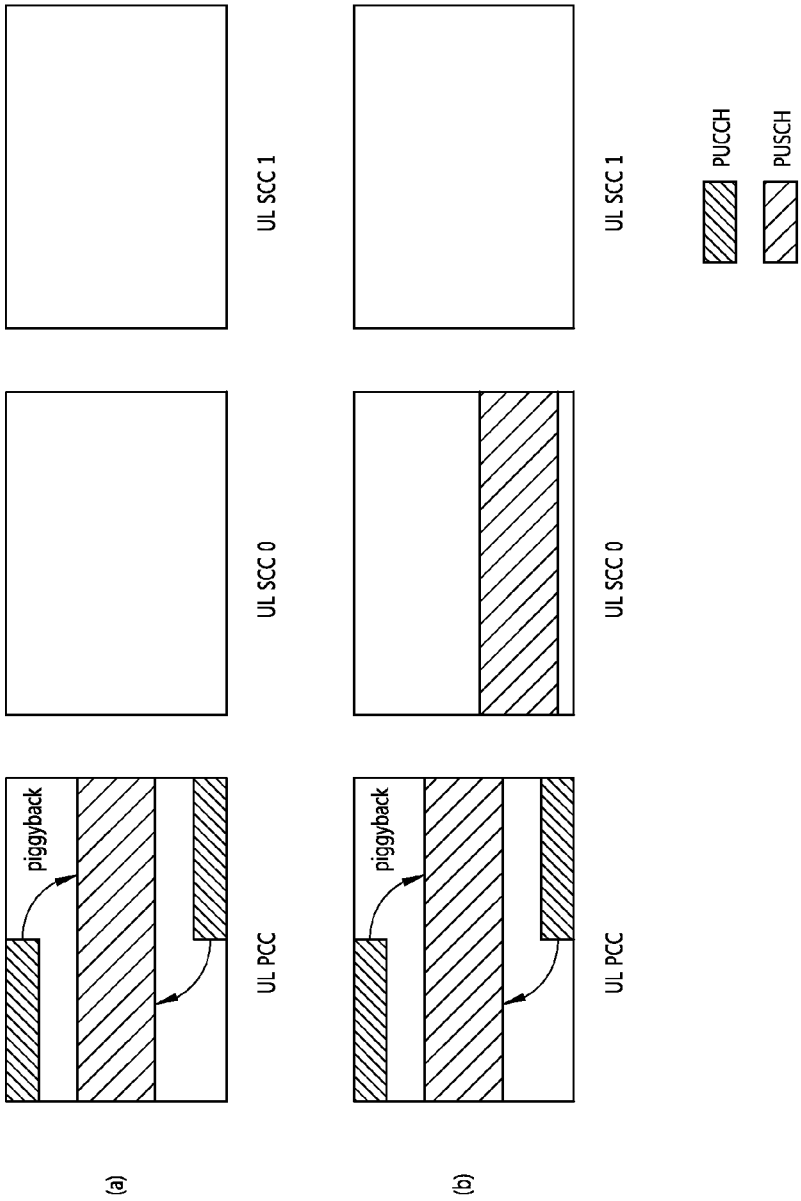


FIG. 20

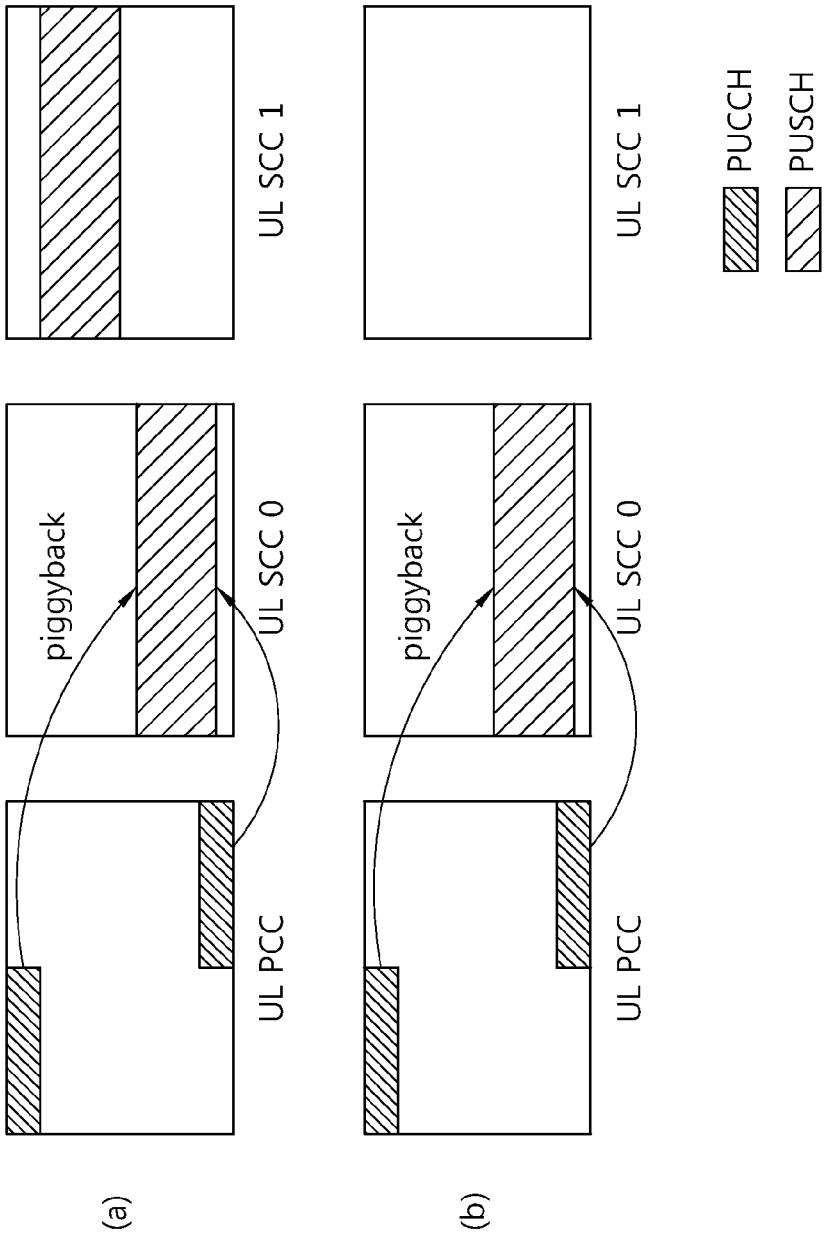


FIG. 21

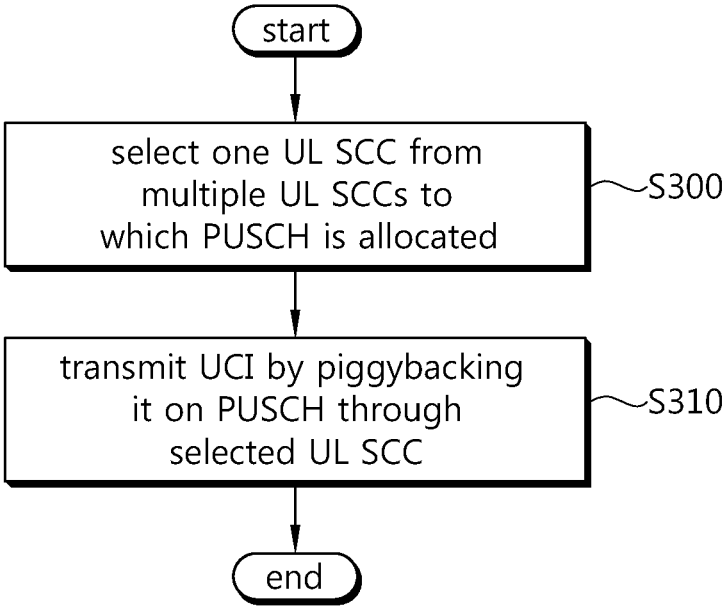

start
select one UL SCC from multiple UL SCCs to which PUSCH is allocated
S300
transmit UCI by piggybacking it on PUSCH through selected UL SCC
S310
end

FIG. 22

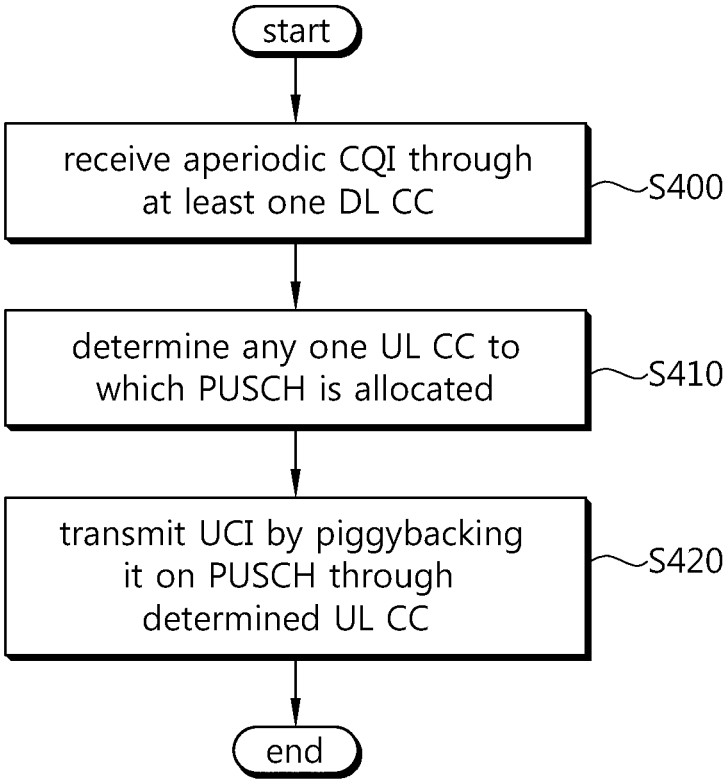
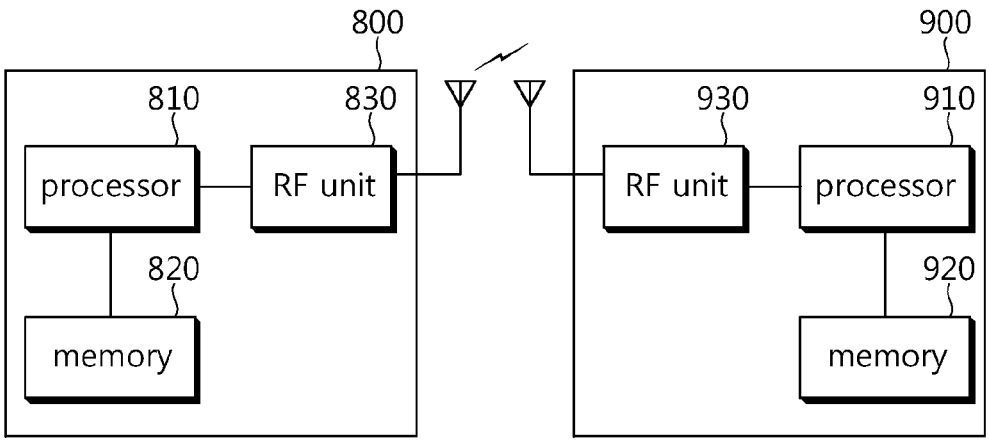

start
receive aperiodic CQI through at least one DL CC
S400
determine any one UL CC to which PUSCH is allocated
S410
transmit UCI by piggybacking it on PUSCH through determined UL CC
S420
end

FIG. 23


800
900
810
830
930
910
processor
RF unit
RF unit
processor
820
920
memory
memory

METHOD AND DEVICE FOR TRANSMITTING AN UPLINK CONTROL SIGNAL IN A WIRELESS COMMUNICATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is the National Phase of PCT/KR2011/005510 filed on Jul. 26, 2011, which claims priority under 35 U.S.C. 119(e) to U.S. Provisional Application Nos. 61/367,859 filed on Jul. 26, 2010, 61/368,271 filed on Jul. 28, 2010, 61/368,659 filed on Jul. 29, 2010, 61/372,444 filed on Aug. 10, 2010, 61/383,334 filed on Sep. 16, 2010 and under 35 U.S.C. 119(a) to Patent Application No. 10-2011-0074146 filed in Republic of Korea on Jul. 26, 2011, all of which are hereby expressly incorporated by reference into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to wireless communication, and more particularly, to a method and device for transmitting an uplink control signal in a wireless communication system.

2. Related Art

Effective transmission/reception methods and utilizations have been proposed for a broadband wireless communication system to maximize efficiency of radio resources. An orthogonal frequency division multiplexing (OFDM) system capable of reducing inter-symbol interference (ISI) with a low complexity is taken into consideration as one of next generation wireless communication systems. In the OFDM, a serially input data symbol is converted into N parallel data symbols, and is then transmitted by being carried on each of separated N subcarriers. The subcarriers maintain orthogonality in a frequency dimension. Each orthogonal channel experiences mutually independent frequency selective fading, and an interval of a transmitted symbol is increased, thereby minimizing inter-symbol interference.

When a system uses the OFDM as a modulation scheme, orthogonal frequency division multiple access (OFDMA) is a multiple access scheme in which multiple access is achieved by independently providing some of available subcarriers to a plurality of users. In the OFDMA, frequency resources (i.e., subcarriers) are provided to the respective users, and the respective frequency resources do not overlap with one another in general since they are independently provided to the plurality of users. Consequently, the frequency resources are allocated to the respective users in a mutually exclusive manner. In an OFDMA system, frequency diversity for multiple users can be obtained by using frequency selective scheduling, and subcarriers can be allocated variously according to a permutation rule for the subcarriers. In addition, a spatial multiplexing scheme using multiple antennas can be used to increase efficiency of a spatial domain.

An uplink control information (UCI) can be transmitted through an uplink control channel, i.e., a physical uplink control channel (PUCCH). The UCI may include various types of information such as a scheduling request (SR), an acknowledgement/non-acknowledgement (ACK/NACK) for a hybrid automatic repeat request (HARQ), a channel quality indicator (CQI), a precoding matrix indicator (PMI), a rank indicator (RI), etc. The PUCCH carries various types of control information according to a format. Transmission of the UCI through the PUCCH may be found in the section 10 of 3GPP (3rd Generation Partnership Project) TS 36.213 V8.8.0 (2009-09).

Meanwhile, a carrier aggregation (CA) system implies a system which supports a broadband by aggregating one or more carriers having a bandwidth narrower than that of a desired broadband when a wireless communication system intends to support the broadband. In the CA system, a user equipment can simultaneously transmit or receive one or a plurality of carriers according to capacity. The conventional transmission technique can be newly defined in the CA system. The CA system may be found in 3GPP TR 36.815 V9.0.0 (2010-3).

Meanwhile, the user equipment may encounter a problem such as inter-modulation distortion (IMD), out-of-band (OOB), etc. In addition, there may be a problem in that the IMD and a cubic metric (CM) are increased when data transmission and UCI transmission are simultaneously performed through a physical uplink shared channel (PUSCH).

Accordingly, effective UCI transmission is required in a CA system.

SUMMARY OF THE INVENTION

The present invention provides a method and device for transmitting an uplink control signal in a wireless communication system. The present invention proposes a method of transmitting an uplink control information (UCI) transmitted periodically through a physical uplink control channel (PUCCH) by piggybacking it on a physical uplink shared channel (PUSCH) and a method of transmitting a UCI aperiodically requested by scheduling of a base station by piggybacking it on a PUSCH.

In an aspect, a method of transmitting an uplink control signal by a user equipment in a wireless communication system is provided. The method includes selecting a single uplink (UL) secondary component carrier (SCC) from a plurality of physical uplink shared channel (PUSCH)-scheduled UL SCCs in a carrier aggregation (CA) system including a plurality of UL component carriers (CCs), and transmitting an uplink control information (UCI) by piggybacking it on the PUSCH scheduled for the selected single UL SCC. The PUSCH is not scheduled in a primary CC (PCC) of the CA system.

The selected single UL SCC may be a UL SCC having a highest or lowest physical or logical index among the plurality of PUSCH-scheduled UL SCCs.

The selected single UL SCC may be selected according to a priority which is set by higher layer signaling.

The priority may be set based on a quality of service (QoS).

The selected single UL SCC may be a UL SCC scheduled in a downlink (DL) PCC.

The selected single UL SCC may be indicated by a UL grant or a DL grant transmitted through a physical downlink control channel (PDCCH).

The selected single UL SCC may be a UL SCC linked to a physical downlink shared channel (PDSCH) to be scheduled by the DL grant or a UL SCC linked to a PDCCH for the PDSCH, or a UL SCC linked to a PUSCH to be scheduled by the UL grant or a UL SCC linked to a physical uplink control channel (PUCCH) for the PUSCH.

The selected single UL SCC may be indicated by a carrier indication field (CIF) in the DL grant or the UL grant.

The UCI may be a periodic UCI transmitted periodically.

In another aspect, a method of transmitting an uplink control signal by a user equipment in a wireless communication system is provided. The method includes receiving a request

of an aperiodic channel quality indicator (CQI) through at least one downlink (DL) component carrier (CC), determining a single uplink (UL) CC from a plurality of physical uplink shared channel (PUSCH)-scheduled UL CCs, and transmitting the aperiodic CQI through a PUSCH scheduled for the single UL CC.

The aperiodic CQI may be transmitted by being multiplexed with a periodic uplink control information (UCI).

The aperiodic CQI and the periodic UCI may be multiplexed in the same CC.

The aperiodic CQI and the periodic UCI may be transmitted by being partially dropped.

Transmission of the aperiodic CQI may be prioritized over transmission of the periodic UCI.

In another aspect, a user equipment in a wireless communication system is provided. The user equipment includes a radio frequency (RF) unit for transmitting or receiving a radio signal, and a processor coupled to the RF unit. The processor is configured for selecting a single uplink (UL) secondary component carrier (SCC) from a plurality of physical uplink shared channel (PUSCH)-scheduled UL SCCs in a carrier aggregation (CA) system including a plurality of UL component carriers (CCs), and transmitting an uplink control information (UCI) by piggybacking it on the PUSCH scheduled for the selected single UL SCC. The PUSCH is not scheduled in a primary CC (PCC) of the CA system.

According to the present invention, an uplink control information (UCI) can be effectively transmitted without the increase in a peak-to-average power ratio (PAPR)/cubic metric (CM).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a wireless communication system.

FIG. **2** shows the structure of a radio frame in 3GPP LTE.

FIG. **3** shows an example of a resource grid of a single downlink slot.

FIG. **4** shows the structure of a downlink subframe.

FIG. **5** shows the structure of an uplink subframe.

FIG. **6** shows an example of the structure of a transmitter in an SC-FDMA system.

FIG. **7** shows an example of a scheme in which the subcarrier mapper maps the complex-valued symbols to the respective subcarriers of the frequency domain.

FIG. **8** shows an example of the structure of a reference signal transmitter for demodulation.

FIG. **9** shows examples of a subframe through which a reference signal is transmitted.

FIG. **10** shows an example of a transmitter using the clustered DFT-s OFDM transmission scheme.

FIG. **11** shows another example of a transmitter using the clustered DFT-s OFDM transmission scheme.

FIG. **12** is another example of a transmitter using the clustered DFT-s OFDM transmission scheme.

FIG. **13** is an exemplary process of handling an uplink shared channel (UL-SCH) transport channel.

FIG. **14** shows an example of a physical resource element to which a data channel and a control channel are mapped in 3GPP LTE.

FIG. **15** is another exemplary process of handling a UL-SCH transport channel.

FIG. **16** shows an example of a transmitter and a receiver which constitute a carrier aggregation system.

FIG. **17** and FIG. **18** show other examples of a transmitter and a receiver which constitute a carrier aggregation system.

FIG. **19** shows an exemplary case in which the existing UCI is transmitted by being piggybacked on a PUSCH.

FIG. **20** shows an exemplary case in which a UCI is transmitted by being piggybacked on a PUSCH according to the proposed invention.

FIG. **21** shows the proposed UL control signal method according to an embodiment of the present invention.

FIG. **22** shows the proposed UL control signal transmission method according to another embodiment of the present invention.

FIG. **23** is a block diagram showing wireless communication system to implement an embodiment of the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

The following technique may be used for various wireless communication systems such as code division multiple access (CDMA), a frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier-frequency division multiple access (SC-FDMA), and the like. The CDMA may be implemented as a radio technology such as universal terrestrial radio access (UTRA) or CDMA2000. The TDMA may be implemented as a radio technology such as a global system for mobile communications (GSM)/general packet radio service (GPRS)/enhanced data rates for GSM evolution (EDGE). The QFDMA may be implemented by a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, E-UTRA (evolved UTRA), and the like. IEEE 802.16m, an evolution of IEEE 802.16e, provides backward compatibility with a system based on IEEE 802.16e. The UTRA is part of a universal mobile telecommunications system (UMTS). 3GPP (3rd generation partnership project) LTE (long term evolution) is part of an evolved UMTS (E-UMTS) using the E-UTRA, which employs the OFDMA in downlink and the SC-FDMA in uplink. LTE-A (advanced) is an evolution of 3GPP LTE.

Hereinafter, for clarification, LTE-A will be largely described, but the technical concept of the present invention is not meant to be limited thereto.

FIG. **1** shows a wireless communication system.

The wireless communication system **10** includes at least one base station (BS) **11**. Respective BSs **11** provide a communication service to particular geographical areas **15***a*, **15***b*, and **15***c* (which are generally called cells). Each cell may be divided into a plurality of areas (which are called sectors). A user equipment (UE) **12** may be fixed or mobile and may be referred to by other names such as MS (mobile station), MT (mobile terminal), UT (user terminal), SS (subscriber station), wireless device, PDA (personal digital assistant), wireless modem, handheld device. The BS **11** generally refers to a fixed station that communicates with the UE **12** and may be called by other names such as eNB (evolved-NodeB), BTS (base transceiver system), access point (AP), etc.

In general, a UE belongs to one cell, and the cell to which a UE belongs is called a serving cell. A BS providing a communication service to the serving cell is called a serving BS. The wireless communication system is a cellular system, so a different cell adjacent to the serving cell exists. The different cell adjacent to the serving cell is called a neighbor cell. A BS providing a communication service to the neighbor cell is called a neighbor BS. The serving cell and the neighbor cell are relatively determined based on a UE.

This technique can be used for downlink or uplink. In general, downlink refers to communication from the BS **11** to the UE **12**, and uplink refers to communication from the UE

12 to the BS 11. In downlink, a transmitter may be part of the BS 11 and a receiver may be part of the UE 12. In uplink, a transmitter may be part of the UE 12 and a receiver may be part of the BS 11.

The wireless communication system may be any one of a multiple-input multiple-output (MIMO) system, a multiple-input single-output (MISO) system, a single-input single-output (SISO) system, and a single-input multiple-output (SIMO) system. The MIMO system uses a plurality of transmission antennas and a plurality of reception antennas. The MISO system uses a plurality of transmission antennas and a single reception antenna. The SISO system uses a single transmission antenna and a single reception antenna. The SIMO system uses a single transmission antenna and a plurality of reception antennas. Hereinafter, a transmission antenna refers to a physical or logical antenna used for transmitting a signal or a stream, and a reception antenna refers to a physical or logical antenna used for receiving a signal or a stream.

FIG. 2 shows the structure of a radio frame in 3GPP LTE.

It may be referred to Paragraph 5 of "Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 8)" to 3GPP (3rd generation partnership project) TS 36.211 V8.2.0 (2008-03). Referring to FIG. 2, the radio frame includes 10 subframes, and one subframe includes two slots. The slots in the radio frame are numbered by #0 to #19. A time taken for transmitting one subframe is called a transmission time interval (TTI). The TTI may be a scheduling unit for a data transmission. For example, a radio frame may have a length of 10 ms, a subframe may have a length of 1 ms, and a slot may have a length of 0.5 ms.

One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in a time domain and a plurality of subcarriers in a frequency domain. Since 3GPP LTE uses OFDMA in downlink, the OFDM symbols are used to express a symbol period. The OFDM symbols may be called by other names depending on a multiple-access scheme. For example, when a single carrier frequency division multiple access (SC-FDMA) is in use as an uplink multiple-access scheme, the OFDM symbols may be called SC-FDMA symbols. A resource block (RB), a resource allocation unit, includes a plurality of continuous subcarriers in a slot. The structure of the radio frame is merely an example. Namely, the number of subframes included in a radio frame, the number of slots included in a subframe, or the number of OFDM symbols included in a slot may vary.

3GPP LTE defines that one slot includes seven OFDM symbols in a normal cyclic prefix (CP) and one slot includes six OFDM symbols in an extended CP.

The wireless communication system may be divided into a frequency division duplex (FDD) scheme and a time division duplex (TDD) scheme. According to the FDD scheme, an uplink transmission and a downlink transmission are made at different frequency bands. According to the TDD scheme, an uplink transmission and a downlink transmission are made during different periods of time at the same frequency band. A channel response of the TDD scheme is substantially reciprocal. This means that a downlink channel response and an uplink channel response are almost the same in a given frequency band. Thus, the TDD-based wireless communication system is advantageous in that the downlink channel response can be obtained from the uplink channel response. In the TDD scheme, the entire frequency band is time-divided for uplink and downlink transmissions, so a downlink transmission by the BS and an uplink transmission by the UE can be simultaneously performed. In a TDD system in which an uplink transmission and a downlink transmission are discriminated in units of subframes, the uplink transmission and the downlink transmission are performed in different subframes.

FIG. 3 shows an example of a resource grid of a single downlink slot.

A downlink slot includes a plurality of OFDM symbols in the time domain and N_{RB} number of resource blocks (RBs) in the frequency domain. The N_{RB} number of resource blocks included in the downlink slot is dependent upon a downlink transmission bandwidth set in a cell. For example, in an LTE system, N_{RB} may be any one of 60 to 110. One resource block includes a plurality of subcarriers in the frequency domain. An uplink slot may have the same structure as that of the downlink slot.

Each element on the resource grid is called a resource element. The resource elements on the resource grid can be discriminated by a pair of indexes (k,l) in the slot. Here, k ($k=0, \ldots, N_{RB}\times 12-1$) is a subcarrier index in the frequency domain, and l is an OFDM symbol index in the time domain.

Here, it is illustrated that one resource block includes 7×12 resource elements made up of seven OFDM symbols in the time domain and twelve subcarriers in the frequency domain, but the number of OFDM symbols and the number of subcarriers in the resource block are not limited thereto. The number of OFDM symbols and the number of subcarriers may vary depending on the length of a cyclic prefix (CP), frequency spacing, and the like. For example, in case of a normal CP, the number of OFDM symbols is 7, and in case of an extended CP, the number of OFDM symbols is 6. One of 128, 256, 512, 1024, 1536, and 2048 may be selectively used as the number of subcarriers in one OFDM symbol.

FIG. 4 shows the structure of a downlink subframe.

A downlink subframe includes two slots in the time domain, and each of the slots includes seven OFDM symbols in the normal CP. First three OFDM symbols (maximum four OFDM symbols with respect to a 1.4 MHz bandwidth) of a first slot in the subframe corresponds to a control region to which control channels are allocated, and the other remaining OFDM symbols correspond to a data region to which a physical downlink shared channel (PDSCH) is allocated.

The PDCCH may carry a transmission format and a resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a PCH, system information on a DL-SCH, a resource allocation of an higher layer control message such as a random access response transmitted via a PDSCH, a set of transmission power control commands with respect to individual UEs in a certain UE group, an activation of a voice over internet protocol (VoIP), and the like. A plurality of PDCCHs may be transmitted in the control region, and a UE can monitor a plurality of PDCCHs. The PDCCHs are transmitted on one or an aggregation of a plurality of consecutive control channel elements (CCE). The CCE is a logical allocation unit used to provide a coding rate according to the state of a wireless channel. The CCE corresponds to a plurality of resource element groups. The format of the PDCCH and an available number of bits of the PDCCH are determined according to an associative relation between the number of the CCEs and a coding rate provided by the CCEs.

The BS determines a PDCCH format according to a DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to the DCI. A unique radio network temporary identifier (RNTI) is masked on the CRC according to the owner or the purpose of the PDCCH. In case of a PDCCH for a particular UE, a unique identifier, e.g., a cell-RNTI (C-RNTI), of the UE, may be masked on the CRC. Or, in case

of a PDCCH for a paging message, a paging indication identifier, e.g., a paging-RNTI (P-RNTI), may be masked on the CRC. In case of a PDCCH for a system information block (SIB), a system information identifier, e.g., a system information-RNTI (SI-RNTI), may be masked on the CRC. In order to indicate a random access response, i.e., a response to a transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be masked on the CRC.

FIG. **5** shows the structure of an uplink subframe.

An uplink subframe may be divided into a control region and a data region in the frequency domain. A physical uplink control channel (PUCCH) for transmitting uplink control information is allocated to the control region. A physical uplink shared channel (PUCCH) for transmitting data is allocated to the data region. If indicated by a higher layer, the user equipment may support simultaneous transmission of the PUCCH and the PUSCH.

The PUCCH for one UE is allocated in an RB pair. RBs belonging to the RB pair occupy different subcarriers in each of 1^{st} slot and a 2^{nd} slot. A frequency occupied by the RBs belonging to the RB pair allocated to the PUCCH changes at a slot boundary. This is called that the RB pair allocated to the PUCCH is frequency-hopped at a slot boundary. Since the UE transmits UL control information over time through different subcarriers, a frequency diversity gain can be obtained. In the figure, m is a location index indicating a logical frequency-domain location of the RB pair allocated to the PUCCH in the subframe.

Uplink control information transmitted on the PUCCH may include a HARQ ACK/NACK, a channel quality indicator (CQI) indicating the state of a downlink channel, a scheduling request (SR) which is an uplink radio resource allocation request, and the like.

The PUSCH is mapped to a uplink shared channel (UL-SCH), a transport channel. Uplink data transmitted on the PUSCH may be a transport block, a data block for the UL-SCH transmitted during the TTI. The transport block may be user information. Or, the uplink data may be multiplexed data. The multiplexed data may be data obtained by multiplexing the transport block for the UL-SCH and control information. For example, control information multiplexed to data may include a CQI, a precoding matrix indicator (PMI), an HARQ, a rank indicator (RI), or the like. Or the uplink data may include only control information.

FIG. **6** shows an example of the structure of a transmitter in an SC-FDMA system.

Referring to FIG. **6**, the transmitter **50** includes a discrete Fourier transform (DFT) unit **51**, a subcarrier mapper **52**, an inverse fast Fourier transform (IFFT) unit **53**, and a cyclic prefix (CP) insertion unit **54**. The transmitter **50** may include a scramble unit (not shown), a modulation mapper (not shown), a layer mapper (not shown), and a layer permutator (not shown), which may be placed in front of the DFT unit **51**.

The DFT unit **51** outputs complex-valued symbols by performing DFT on input symbols. For example, when Ntx symbols are input (where Ntx is a natural number), a DFT size is Ntx. The DFT unit **51** may be called a transform precoder. The subcarrier mapper **52** maps the complex-valued symbols to the respective subcarriers of the frequency domain. The complex-valued symbols may be mapped to resource elements corresponding to a resource block allocated for data transmission. The subcarrier mapper **52** may be called a resource element mapper. The IFFT unit **53** outputs a baseband signal for data (that is, a time domain signal) by performing IFFT on the input symbols. The CP insertion unit **54** copies some of the rear part of the baseband signal for data and inserts the copied parts into the former part of the baseband signal for data. Orthogonality may be maintained even in a multi-path channel because inter-symbol interference (ISI) and inter-carrier interference (ICI) are prevented through CP insertion.

FIG. **7** shows an example of a scheme in which the subcarrier mapper maps the complex-valued symbols to the respective subcarriers of the frequency domain. Referring to FIG. **7**(*a*), the subcarrier mapper maps the complex-valued symbols, outputted from the DFT unit, to subcarriers contiguous to each other in the frequency domain. '0' is inserted into subcarriers to which the complex-valued symbols are not mapped. This is called localized mapping. In a 3GPP LTE system, a localized mapping scheme is used. Referring to FIG. **7**(*b*), the subcarrier mapper inserts an (L−1) number of '0' every two contiguous complex-valued symbols which are outputted from the DFT unit (L is a natural number). That is, the complex-valued symbols outputted from the DFT unit are mapped to subcarriers distributed at equal intervals in the frequency domain. This is called distributed mapping. If the subcarrier mapper uses the localized mapping scheme as in FIG. **7**(*a*) or the distributed mapping scheme as in FIG. **7**(*b*), a single carrier characteristic is maintained.

FIG. **8** shows an example of the structure of a reference signal transmitter for demodulation.

Referring to FIG. **8**, the reference signal transmitter **60** includes a subcarrier mapper **61**, an IFFT unit **62**, and a CP insertion unit **63**. Unlike the transmitter **50** of FIG. **6**, in the reference signal transmitter **60**, a reference signal is directly generated in the frequency domain without passing through the DFT unit **51** and then mapped to subcarriers through the subcarrier mapper **61**. Here, the subcarrier mapper may map the reference signal to the subcarriers using the localized mapping scheme of FIG. **7**(*a*).

FIG. **9** shows examples of a subframe through which a reference signal is transmitted. The structure of a subframe in FIG. **9**(*a*) shows a case of a normal CP. The subframe includes a first slot and a second slot. Each of the first slot and the second slot includes 7 OFDM symbols. The 14 OFDM symbols within the subframe are assigned respective symbol indices 0 to 13. Reference signals may be transmitted through the OFDM symbols having the symbol indices 3 and 10. The reference signals may be transmitted using a sequence. A Zadoff-Chu (ZC) sequence may be used as the reference signal sequence. A variety of ZC sequences may be generated according to a root index and a cyclic shift value. A BS may estimate the channels of a plurality of UEs through an orthogonal sequence or a quasi-orthogonal sequence by allocating different cyclic shift values to the UEs. The positions of the reference signals occupied in the two slots within the subframe in the frequency domain may be identical with each other or different from each other. In the two slots, the same reference signal sequence is used. Data may be transmitted through the remaining SC-FDMA symbols other than the SC-FDMA symbols through which the reference signals are transmitted. The structure of a subframe in FIG. **9**(*b*) shows a case of an extended CP. The subframe includes a first slot and a second slot. Each of the first slot and the second slot includes 6 SC-FDMA symbols. The 12 SC-FDMA symbols within the subframe are assigned symbol indices 0 to 11. Reference signals are transmitted through the SC-FDMA symbols having the symbol indices 2 and 8. Data is transmitted through the remaining SC-FDMA symbols other than the SC-FDMA symbols through which the reference signals are transmitted.

Although not shown in FIG. **9**, a sounding reference signal (SRS) may be transmitted through the OFDM symbols within the subframe. The SRS is a reference signal for UL schedul-

ing which is transmitted from UE to a BS. The BS estimates a UL channel through the received SRS and uses the estimated UL channel in UL scheduling.

A clustered DFT-s OFDM transmission scheme is a modification of the existing SC-FDMA transmission scheme and is a method of dividing data symbols, subjected to a precoder, into a plurality of subblocks, separating the subblocks, and mapping the subblocks in the frequency domain.

FIG. **10** shows an example of a transmitter using the clustered DFT-s OFDM transmission scheme. Referring to FIG. **10**, the transmitter **70** includes a DFT unit **71**, a subcarrier mapper **72**, an IFFT unit **73**, and a CP insertion unit **74**. The transmitter **70** may further include a scramble unit (not shown), a modulation mapper (not shown), a layer mapper (not shown), and a layer permutator (not shown), which may be placed in front of the DFT unit **71**.

Complex-valued symbols outputted from the DFT unit **71** are divided into N subblocks (N is a natural number). The N subblocks may be represented by a subblock #1, a subblock #2, . . . , a subblock #N. The subcarrier mapper **72** distributes the N subblocks in the frequency domain and maps the N subblocks to subcarriers. The NULL may be inserted every two contiguous subblocks. The complex-valued symbols within one subblock may be mapped to subcarriers contiguous to each other in the frequency domain. That is, the localized mapping scheme may be used within one subblock.

The transmitter **70** of FIG. **10** may be used both in a single carrier transmitter or a multi-carrier transmitter. If the transmitter **70** is used in the single carrier transmitter, all the N subblocks correspond to one carrier. If the transmitter **70** is used in the multi-carrier transmitter, each of the N subblocks may correspond to one carrier. Alternatively, even if the transmitter **70** is used in the multi-carrier transmitter, a plurality of subblocks of the N subblocks may correspond to one carrier. Meanwhile, in the transmitter **70** of FIG. **10**, a time domain signal is generated through one IFFT unit **73**. Accordingly, in order for the transmitter **70** of FIG. **10** to be used in a multi-carrier transmitter, subcarrier intervals between contiguous carriers in a contiguous carrier allocation situation must be aligned.

FIG. **11** shows another example of a transmitter using the clustered DFT-s OFDM transmission scheme. Referring to FIG. **11**, the transmitter **80** includes a DFT unit **81**, a subcarrier mapper **82**, a plurality of IFFT units **83-1**, **83-2**, . . . , **83**-N (N is a natural number), and a CP insertion unit **84**. The transmitter **80** may further include a scramble unit (not shown), a modulation mapper (not shown), a layer mapper (not shown), and a layer permutator (not shown), which may be placed in front of the DFT unit **71**.

IFFT is individually performed on each of N subblocks. An n^{th} IFFT unit **38**-*n* outputs an n^{th} baseband signal (n=1, 2, . . . , N) by performing IFFT on a subblock #n. The n^{th} baseband signal is multiplied by an n^{th} carrier signal to produce an n^{th} radio signal. After the N radio signals generated from the N subblocks are added, a CP is inserted by the CP insertion unit **314**. The transmitter **80** of FIG. **11** may be used in a discontiguous carrier allocation situation where carriers allocated to the transmitter are not contiguous to each other.

FIG. **12** is another example of a transmitter using the clustered DFT-s OFDM transmission scheme. FIG. **12** is a chunk-specific DFT-s OFDM system performing DFT precoding on a chunk basis. This may be called Nx SC-FDMA. Referring to FIG. **12**, the transmitter **90** includes a code block division unit **91**, a chunk division unit **92**, a plurality of channel coding units **93-1**, . . . , **93**-N, a plurality of modulators **94-1**, **4914**-N, a plurality of DFT units **95-1**, . . . , **95**-N, a plurality of subcarrier mappers **96-1**, . . . , **96**-N, a plurality of IFFT units **97-1**, . . . , **97**-N, and a CP insertion unit **98**. Here, N may be the number of multiple carriers used by a multi-carrier transmitter. Each of the channel coding units **93-1**, **93**-N may include a scramble unit (not shown). The modulators **94-1**, . . . , **94**-N may also be called modulation mappers. The transmitter **90** may further include a layer mapper (not shown) and a layer permutator (not shown) which may be placed in front of the DFT units **95-1**, . . . , **95**-N.

The code block division unit **91** divides a transmission block into a plurality of code blocks. The chunk division unit **92** divides the code blocks into a plurality of chunks. Here, the code block may be data transmitted by a multi-carrier transmitter, and the chunk may be a data piece transmitted through one of multiple carriers. The transmitter **90** performs DFT on a chunk basis. The transmitter **90** may be used in a discontiguous carrier allocation situation or a contiguous carrier allocation situation.

FIG. **13** is an exemplary process of handling an uplink shared channel (UL-SCH) transport channel. Data is delivered to a coding unit in a format of at most one transport block for each transmission time interval (TTI). The process of handling the UL-SCH transport channel of FIG. **13** is also applicable to each UL-SCH transport channel of each UL cell.

Referring to FIG. **13**, in step S**100**, a cyclic redundancy check (CRC) is attached to a transport block. By attaching the CRC, error detection can be supported. A size of the transport block may be denoted as A, a size of a parity bit may be denoted as L, and B may be defined as B=A+L.

In step S**110**, the CRC-attached transport block is segmented into a plurality of code blocks, and a CRC is attached to each code block. A size of each code block may be denoted as Kr, where r is a code block number.

In step S**120**, channel coding is performed on each code block. In this case, the channel coding can be performed using a turbo coding scheme. Since a coding rate of the turbo coding is ⅓, three coded streams are generated. Each coded stream having a code block number r has a size of Dr.

In step S**130**, rate matching is performed on each channel-coded code block. When the code block number is r, the number of rate-matched bits can be expressed as Er.

In step S**140**, the respective rate-matched code blocks are concatenated with each other. G denotes the total number of bits for the concatenated code blocks. Herein, a bit used for control information transmission is excluded from a given transport block on N_L transport layers. In this case, the control information can be multiplexed with UL-SCH transmission.

In step S**141** to step S**143**, channel coding is performed on the control information. The control information may include channel quality information including a CQI and/or a PMI, an HARQ-ACK, an RI, etc. It is assumed hereinafter that the CQI includes the PMI. For each piece of control information, a different coding rate is applied according to the number of different coding symbols. When the control information is transmitted through a PUSCH, channel coding is independently performed on the CQI, the RI, and the HARQ-ACK. Although it is assumed in the present embodiment that the CQI, the RI, and the HARQ-ACK are channel-coded respectively in step S**141**, step S**142**, and step S**143**, the present invention is not limited thereto.

In step S**150**, data and control information are multiplexed. In this case, HARQ-ACK information exists in both of two slots of a subframe, and can be mapped to resources around a demodulation reference signal (DMRS). By multiplexing the data and the control information, the data and the control information can be mapped to different modulation symbols. Meanwhile, when one or more UL-SCH transport blocks are

transmitted in a subframe of a UL cell, CQI information can be multiplexed with data on a UL-SCH transport block having a highest modulation and coding scheme (MCS).

In step **S160**, channel interleaving is performed. The channel interleaving can be performed in association with PUSCH resource mapping. By the channel interleaving, a modulation symbol can be time-first mapped in a transmit waveform. HARQ-ACK information can be mapped to resources around a UL DMRS. RI information can be mapped around resources used by the HARQ-ACK information.

FIG. **14** shows an example of a physical resource element to which a data channel and a control channel are mapped in 3GPP LTE. A horizontal axis denotes a virtual subcarrier which is an input of discrete Fourier transform (DFT). A vertical axis denotes an SC-FDMA symbol. A reference signal is mapped to a 4^{th} SC-FDMA symbol of each slot. Data and a CQI are mapped in a time-first manner. The data and the CQI can be multiplexed in a serial link manner. An encoded HARQ-ACK is mapped to an SC-FDMA symbol located next to the SC-FDMA symbol to which the reference signal is mapped. A resource used for the HARQ-ACK may be located in a last portion of a virtual subcarrier. HARQ-ACK information may exist in both of two slots in a subframe. Irrespective of whether the HARQ-ACK is transmitted, an RI can be rate-matched next to a resource element to which the HARQ-ACK is mapped. The maximum number of SC-FDMA symbols to which the HARQ-ACK and the RI are mapped may be 4.

FIG. **15** is another exemplary process of handling a UL-SCH transport channel. In step **S200**, a UE recognizes an RI of a UL-SCH. In step **S210**, the UE determines a rank of the UL-SCH to a rank of a control channel. In this case, the number of information bits of the control channel may be extended according to the rank of the control channel. The number of information bits of the control channel can be extended by using simple repetition or a circular buffer. For example, if the information bit is [a0 a1 a2 a3] and the number of ranks is 2, the extended information bits may be [a0 a1 a2 a3 a0 a1 a2 a3] by using the simple repetition. By limiting the rank of the control channel to the rank of the data channel, a signaling overhead can be avoided. Since a DMRS is precoded by using the same precoding as that used in a data part, if the rank of the control channel differs from the rank of the data channel, additional signaling may be necessary for a PMI for the control channel. In this case, even if the number of effective ranks of the control channel is 1, the rank of the control channel can be determined to be equal to the rank of the data channel.

In step **S220**, the UE multiplexes the data and the control channel. In step **S230**, the UE performs a channel interleaving process. In step **S240**, the UE modulates the data and the control channel by using a modulation scheme such as quadrature phase shift keying (QPSK), 16 quadrature amplitude modulation (QAM), 64 QAM, or the like according to an MCS table. The modulation scheme of step **S240** can also be performed in any steps of the aforementioned process of handling the UL-SCH transport channel of FIG. **15**. Subsequently, DFT, MIMO precoding, resource element mapping, etc., can be performed.

When assuming two codewords, channel coding is performed for each codeword, and rate matching is performed according to the given MCS table. An encoded information bit can be scrambled in a cell-specific, UE-specific, or codeword-specific manner. Subsequently, the codeword can be mapped to a layer. In this case, layer shifting or layer permutation can be performed.

3GPP LTE-A supports a carrier aggregation (CA) system. The CA system may refer to 3GPP TR 36.815 V9.0.0 (2010-03).

A carrier aggregation (CA) system implies a system that configures a wideband by aggregating one or more carriers having a bandwidth smaller than that of a target wideband when the wireless communication system intends to support the wideband. The CA system can also be referred to as other terms such as a bandwidth aggregation system, or the like. The carrier aggregation system can be divided into a contiguous carrier aggregation system in which carriers are contiguous to each other and a non-contiguous carrier aggregation system in which carriers are separated from each other. In the contiguous carrier aggregation system, a frequency spacing may exist between respective carriers. A carrier which is a target when aggregating one or more carriers can directly use a bandwidth that is used in the legacy system in order to provide backward compatibility with the legacy system. For example, a 3^{rd} generation partnership project (3GPP) long-term evolution (LTE) system can support a bandwidth of 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz, and a 3GPP LTE-A system can configure a wideband of 20 MHz or higher by using only the bandwidth of the 3GPP LTE system. Alternatively, the wideband can be configured by defining a new bandwidth without having to directly use the bandwidth of the legacy system.

In the carrier aggregation system, a user equipment (UE) can transmit or receive one or multiple carriers simultaneously according to capacity. An LTE-A UE can transmit or receive the multiple carriers simultaneously. An LTE Rel-8 UE can transmit or receive only one carrier when each of carriers constituting the carrier aggregation system is compatible with an LTE Rel-8 system. Therefore, when the number of carriers used in an uplink (UL) is equal to the number of carriers used in a downlink (DL), it is necessary to configure such that all component carriers (CCs) are compatible with the LTE Rel-8 system.

In order to efficiently use multiple carriers, the multiple carriers can be managed by media access control (MAC). In order to transmit/receive the multiple carriers, both a transmitter and a receiver must be able to transmit/receive the multiple carriers.

FIG. **16** shows an example of a transmitter and a receiver which constitute a carrier aggregation system.

In the transmitter of FIG. **16**(*a*), one MAC transmits and receives data by managing and operating all of n carriers. This is also applied to the receiver of FIG. **16**(*b*). From the perspective of the receiver, one transport block and one HARQ entity may exist per CC. A UE can be scheduled simultaneously for multiple carriers. The carrier aggregation system of FIG. **16** can apply both to a contiguous carrier aggregation system and a non-contiguous carrier aggregation system. The respective carriers managed by one MAC do not have to be contiguous to each other, which results in flexibility in terms of resource management.

FIG. **17** and FIG. **18** show other examples of a transmitter and a receiver which constitute a carrier aggregation system.

In the transmitter of FIG. **17**(*a*) and the receiver of FIG. **17**(*b*), one MAC manages only one carrier. That is, the MAC and the carrier are 1:1 mapped. In the transmitter of FIG. **18**(*a*) and the receiver of FIG. **18**(*b*), a MAC and a carrier are 1:1 mapped for some carriers, and regarding the remaining carriers, one MAC controls multiple carriers. That is, various combinations are possible based on a mapping relation between the MAC and the carrier.

The carrier aggregation system of FIG. **16** to FIG. **18** includes n carriers. The respective carriers may be contiguous

to each other or may be separated from each other. The carrier aggregation system can apply both to a UL and a DL. In a TDD system, each carrier is configured to be able to perform UL transmission and DL transmission. In an FDD system, multiple carriers can be used by dividing them for a UL and a DL. In a typical TDD system, the number of CCs used in the UL is equal to that used in the DL, and each carrier has the same bandwidth. The FDD system can configure an asymmetric carrier aggregation system by allowing the number of carriers and the bandwidth to be different between the UL and the DL.

Meanwhile, the concept of a cell can be applied in the LTE-A system. The cell is an entity configured by combining at least one unit of DL resources and selectively included UL resources from the perspective of a UE. That is, one cell must include at least one unit of DL resources, but may not include UL resources. The one unit of DL resources may be one DL CC. A linkage between a carrier frequency of a DL resource and a carrier frequency of a UL resource can be indicated by an SIB2 transmitted using the DL resource. Although a component carrier (CC) will be taken as an example in the following descriptions of the present invention, it is apparent that the CC can be replaced with a cell.

A cell type can be classified according to an allocation method. First, the number of cells allocated to an entire system may be fixed. For example, the number of cells allocated to the entire system may be 8. All or some of the cells allocated to the entire system may be allocated by radio resource control (RRC) signaling of a higher layer. The cell allocated by the RRC signaling is called a configured cell. That is, the configured cell may imply a cell allocated to be usably by the system among the cells allocated to the entire system. All or some of the configured cells may be allocated by media access control (MAC) signaling. The cell allocated by the MAC signaling can be called an activated cell. Among the configured cells, the remaining cells other than the activated cell can be called a deactivated cell. All or some of the activated cells are allocated to the UE by using L1/L2 signaling. The cell allocated by using the L1/L2 signaling can be called a scheduled cell. The scheduling cell can receive data through a PDSCH by using a DL resource in a cell, and can transmit data through a PUSCH by using a UL resource.

Hereinafter, a UL control signal transmission method proposed in the present invention will be described.

In order to achieve effective UCI transmission or to solve a problem of IMD and OOB in a UE, the UE can transmit a UCI through a defined single UL primary CC (PCC). An ACK/NACK feedback corresponding to a plurality of DL CCs can be transmitted through the UL PCC in a carrier aggregation system. Although the UL PCC is defined only for a single UL CC from the perspective of the UE, if the UE has two or more radio frequency (RF) devices, the UL PCC can be defined in accordance therewith.

Meanwhile, in LTE rel-8/9, simultaneous transmission of the PUSCH and the PUCCH of the UE is not allowed. This is to maintain a single carrier property. Accordingly, in a case where the UCI such as ACK/NACK for a scheduled PDSCH, a periodic channel state information (CSI), or the like must be transmitted through the PUCCH, a problem may occur when data must be transmitted simultaneously through the PUSCH. To solve such a problem, it can be proposed to transmit the UCI by piggybacking it on the PUSCH. By using the piggyback-type transmission, the UCI can be transmitted through the PUSCH instead of being transmitted through the PUCCH. Accordingly, multiple channels can be prevented from simultaneous transmission, and thus it is possible to prevent an increased PAPR/CM problem or an IMD problem.

The piggyback-type transmission method can be applied to avoid simultaneous transmission of multiple channels in the carrier aggregation system. Although it is assumed hereinafter that the PUCCH is allocated only to the UL PCC for convenience of explanation, the present invention is not limited thereto. Hereinafter, a method of transmitting a UCI that can be transmitted through a PUCCH by piggybacking it on a PUSCH according to scheduling of the PUSCH will be described.

FIG. **19** shows an exemplary case in which the existing UCI is transmitted by being piggybacked on a PUSCH. In FIG. **19**-(*a*), the PUSCH is allocated only to a UL PCC, and the UCI is transmitted by being piggybacked on the PUSCH allocated to the UL PCC. In FIG. **19**-(*b*), the PUSCH is allocated to a UL PCC and a UL secondary CC (SCC) #0. Similarly to FIG. **19**-(*a*), the UCI is transmitted by being piggybacked on the PUSCH allocated to the UL PCC.

If the PUSCH is allocated to a plurality of UL SCCs and is not scheduled in the UL PCC, various methods can be considered to determine a UL SCC on which a UCI is piggybacked among the plurality of UL SCCs. In the following description, when it is said that the PUSCH is not scheduled in the UL PCC, it may imply that data is not transmitted through the PUSCH as well as a retransmission case. In a UL HARQ case, a UE can perform a synchronous non-adaptive HARQ operation even if there is no scheduling based on a UL grant. That is, when the PUSCH is not scheduled in the UL PCC, it implies that there is neither data transmission through the PUSCH nor data retransmission using HARQ.

1) First, the UE can piggyback the UCI to a corresponding PUSCH by selecting any one UL CC implicitly configured among a plurality of UL CCs to which PUSCHs are allocated.

- Among PUSCH-scheduled UL SCCs, the UCI can be piggybacked to a PUSCH of a UL SCC having a highest or lowest physical CC index or logical CC index.
- Among PUSCH-activated UL SCCs, the UCI can be piggybacked to a PUSCH of a UL SCC having a highest or lowest physical CC index or logical CC index.
- Among PUSCH-configured UL SCCs, the UCI can be piggybacked to a PUSCH of a UL SCC having a highest or lowest physical CC index or logical CC index.
- The UL SCC can be selected according to a size of a transmission block (TB). For example, the UCI can be piggybacked on a PUSCH of a UL SCC having a greatest size of a scheduled UL resource or a UL SCC having a greatest modulation and coding scheme (MCS) level.
- A UL SCC on which the UCI is piggybacked can be selected according to a priority of a UL SCC configured by higher layer signaling. The priority of the UL SCC can be semi-statically changed by higher layer signaling. The priority of the UL SCC on which the UCI is piggybacked can be configured by an index of an SCC, and can also be configured based on a quality of service (QoS) of SCCs. In this case, a BS can report the QoS for the UL SCC, and advantageously, there is no need to select a new priority. Alternatively, one priority can be selected from a plurality of implicitly predefined priorities by higher layer signaling, and the UE can determine a UL SCC on which the UCI is piggybacked according to the selected priority. There is an advantage in that flexibility can be ensured in operations of the BS and the UE according to the plurality of priorities.
- The UCI can be piggybacked on a UL SCC to be scheduled in a DL PCC. If two or more UL SCCs are scheduled in the DL PCC, the UL SCC on which the UCI is piggybacked can be determined according to any one of methods described above.

In case of semi-persistent scheduling and non-adaptive retransmission, the UL SCC can be determined in the same manner as that used for an initially transmitted grant.

FIG. **20** shows an exemplary case in which a UCI is transmitted by being piggybacked on a PUSCH according to the proposed invention. In FIG. **20**-(*a*), the PUSCH is not allocated to a UL PCC, and is allocated to a UL SCC #0 and a UL SCC #1. The UCI is transmitted by being piggybacked on the PUSCH allocated to the UL SCC #0. In this case, when selecting a UL SCC on which the UCI is piggybacked between the UL SCC #0 and the UL SCC #1, any one of the aforementioned various methods can be applied. For example, between the PUSCH-scheduled UL SCC #0 and UL SCC #1, the UCI can be piggybacked on the UL SCC #0 having a lowest physical CC index or logical CC index. In FIG. **20**-(*b*), the PUSCH is not allocated to the UL PCC, and is allocated to the UL SCC #01. The UCI is transmitted by being piggybacked on the PUSCH allocated to the UL SCC #0.

Meanwhile, the aforementioned present invention is also applicable to a case in which a specific UL SCC is used for data retransmission. For example, if there are three configured UL CCs and if, in any one subframe, a PUSCH is not scheduled in a UL PCC and data is retransmitted in a UL SCC #0 and a UL SCC #1 without having to use a UL grant, then the UCI can be piggybacked on the UL SCC #0 having the lowest physical CC index or logical CC index. If the PUSCH is not scheduled in the UL PCC and data is retransmitted only in the UL SCC #1, the UCI can be piggybacked in the UL SCC #1.

2) In another method, a BS can report an index of a UL SCC, on which the UCI is piggybacked, to a UE through a PDCCH or radio resource control (RRC).

The BS can report an index of the UL SCC, on which the UCI is piggybacked, to the UE through a DL grant. In this case, the index of the UL SCC can be implicitly or explicitly indicated. If the UL SCC is implicitly indicated, the UCI can be piggybacked on a UL SCC linked to a PDCCH for a PDSCH to be scheduled by the DL grant. Alternatively, the UCI can be piggybacked on a UL SCC linked to a DL CC for transmitting a PDSCH to be scheduled by the DL grant. In a case in which the index of the UL SCC is explicitly indicated, if cross-carrier scheduling is possible, the UCI can be piggybacked on a UL SCC linked to a DL CC indicated by a carrier indication field (CIF) in the DL grant. If the number of UL SCCs linked to the DL CC is greater than or equal to 2, the UCI can be piggybacked by selecting one specific UL SCC. For example, the UCI can be piggybacked by selecting one UL SCC having a lowest or highest CC index. In this case, the index of the UL SCC can be indicated by reusing the existing CIF or transmit power control (TPC) field, or can be indicated by newly defining the CIF or TPC field.

The BS can report an index of a UL SCC, on which the UCI is piggybacked, to the UE through the UL grant. In this case, the index of the UL SCC can be indicated implicitly or explicitly. The same method as that used in the aforementioned DL grant case can be applied.

The BS can report the index of the UL SCC, on which the UCI is piggybacked, to the UE through higher layer signaling. The UL SCC on which the UCI is piggybacked can be selected according to a priority of the UL SCC configured by the higher layer signaling. The priority of the UL SCC on which the UCI is piggybacked can be determined by the index of the SCC, or can be determined based on QoS of SCCs. Among a plurality of implicitly pre-defined priories, one priority can be determined through higher layer signaling.

Meanwhile, the aforementioned methods of selecting the UL SCC can be applied by combining two or more methods.

3) As another method, the UE can drop either UCI transmission through a PUCCH or data transmission through a PUSCH. The dropping of transmission can be predetermined according to a priority, or can be indicated through PDCCH signaling or RRC signaling. If the data transmission through the PUSCH is dropped, only the PUCCH can be transmitted in at least one UL CC. In this case, the dropping of the data transmission through the PUSCH can be applied on a UL CC basis. If the UCI transmission through the PUCCH is dropped, the UCI is not piggybacked on the PUSCH allocated to at least one UL CC.

4) Meanwhile, the present invention is also applicable to a case in which retransmission is performed based on HARQ. In LTE-A, HARQ can be performed on an HARQ entity basis, where the HARQ entity may be one CC. For example, if initial transmission is performed through a UL CC #2, retransmission thereof is also performed through the UL CC #2.

For example, it is assumed that initial transmission is performed in a UL PCC, a UL SCC #0, and a UL SCC #1 in such a manner that, in the UL PCC and the UL SCC #0, data is successfully decoded and thus ACK is transmitted through a physical HARQ indicator channel (PHICH), and in the UL SCC #1, data decoding fails and thus NACK is transmitted through the PHICH. Data is retransmitted in the UL SCC #1. In this case, the UCI is simultaneously transmitted through the PUCCH allocated to the UL PCC, and if there is no PUSCH scheduled in the UL PCC, the UCI can be transmitted by being piggybacked on the PUSCH of the UL SCC #1. Information regarding a UL SCC on which the UCI is piggybacked may be included in a UL grant transmitted in a DL PCC.

Alternatively, it is assumed that initial transmission is performed in a UL PCC, a UL SCC #0, and a UL SCC #1 in such a manner that, in the UL PCC, data is successfully decoded and thus ACK is transmitted through a PHICH, and in the UL SCC #0 and the UL SCC #1, data decoding fails and thus NACK is transmitted through the PHICH. Data is retransmitted in the UL SCC #0 and the UL SCC #1. In this case, the UCI can be piggybacked on the UL SCC indicated by the UL grant. For example, if the UL grant for the UL SCC #0 is transmitted, the UCI can be piggybacked on the UL SCC #0. In this case, the UL grant indicating the UL SCC #0 can be indicated from a DL PCC or a DL CC linked to the UL SCC #0.

FIG. **21** shows the proposed UL control signal method according to an embodiment of the present invention.

In step **S300**, a UE selects any one UL SCC from a plurality of PUSCH-scheduled UL SCCs. The aforementioned various methods can be applied when selecting any one of the UL SCCs. In step **S310**, the UE transmits the UCI by piggybacking it on the scheduled PUSCH through the selected one UL SCC.

Although a case of not enabling simultaneous transmission of data through a PUSCH and a UCI through a PUSCH is assumed in the above description, the UCI can be piggybacked also in a case of enabling simultaneous transmission of the data through the PUSCH and the UCI through the PUCCH. That is, the UCI can be transmitted by using a method of piggybacking the UCI transmitted in a UL PCC on

a PUSCH scheduled in the UL PCC. Otherwise, the data and the UCI can be simultaneously transmitted without being piggybacked.

Although a case in which a periodic UCI is piggybacked on a PUSCH is taken as an example to describe the present invention, the present invention is also equally applicable to a case in which an aperiodic CQI is transmitted. That is, if an aperiodic CQI request is received from at least one DL CC, the UCI can be transmitted through a PUSCH scheduled in one selected UL CC according to the aforementioned present invention.

If the aperiodic CQI request is received from one DL CC, the aperiodic CQI can be transmitted through a UL CC indicated in a UL grant irrespective of the aperiodic CQI request for a plurality of DL CCs. In this case, the UL CC indicated in the UL grant may be a UL CC which is system information block (SIB)-2 linked to the DL CC for transmitting the aperiodic CQI request, or may be a UL CC indicated by a CIF in the DL grant.

If the aperiodic CQI request is received from a plurality of DL CCs, a UL CC for transmitting the aperiodic CQI can be selected by using an implicit or explicit method similarly to the aforementioned method of selecting a UL SCC on which the UCI is piggybacked. That is, a UL CC for transmitting the aperiodic CQI can be selected according to an index of the UL CC or according to a size of a transport block or according to a priority determined by higher layer signaling. When determining the priority, a UL PCC can be always determined as the most preferential UL CC. In this case, the priority of selecting the UL CC can be determined in the remaining UL CCs except for the most preferential UL PCC. Alternatively, according to whether the UCI can be transmitted through a plurality of UL CCs in one subframe, the UCI can be transmitted on each UL CC indicated by a UL grant if the UCI can be transmitted through the plurality of UL CCs.

A periodic UCI and an aperiodic CQI can be transmitted by being multiplexed. If the periodic UCI and the aperiodic CQI are transmitted in the same UL CC as information regarding the same DL CC, the periodic UCI and the aperiodic CQI can be always transmitted or transmission of the periodic UCI can be dropped. Even in a case of dropping the transmission of the periodic UCI, ACK/NACK which is piggybacked for a plurality of DL CCs can be always transmitted preferentially. If the periodic UCI and the aperiodic CQI are transmitted in the same UL CC as information regarding different DL CCs, the periodic UCI and the aperiodic CQI can be always transmitted or transmission of the periodic UCI can be dropped similarly to the above case. Alternatively, the periodic UCI and/or the aperiodic CQI can be transmitted respectively by using the aforementioned methods.

Alternatively, if the periodic UCI and the aperiodic CQI are transmitted in the same UL CC as information regarding different DL CCs, a priority of the aperiodic CQI and the periodic UCI can be determined and then transmission thereof can be partially dropped. If transmission of a plurality of periodic UCIs for one or a plurality of DL CCs is requested and transmission of aperiodic CQI for one DL CC is triggered, transmission of the periodic UCI in a DL CC in which transmission of the aperiodic CQI is triggered can be preferentially dropped. Accordingly, backward compatibility with LTE rel-8/9 can be maintained. Alternatively, while preferentially transmitting the aperiodic CQI of a DL CC for which the transmission of the aperiodic CQI is triggered, the periodic UCI for at least one DL CC can be transmitted according to a priority among periodic UCIs for a plurality of DL CCs. In this case, the aforementioned various methods can be applied as a method of selecting one UCI for transmitting the periodic UCI. In addition, the DL CC for transmitting the aperiodic CQI may be excluded when determining a priority for transmitting the periodic UCI.

Even in a case in which a plurality of periodic UCIs are transmitted for one or a plurality of DL CCs and transmission of an aperiodic CQI is triggered for the plurality of DL CCs, transmission of the periodic UCI in a plurality of DL CCs in which transmission of the aperiodic CQI is triggered can be preferentially dropped. Alternatively, the aperiodic CQI for the plurality of DL CCs can be transmitted through one or a plurality of UL CCs indicated by a UL grant including an aperiodic CQI transmission request by preferentially transmitting the aperiodic CQI of the plurality of DL CCs in which the aperiodic CQI is triggered, and the periodic UCI for at least one DL CC can be transmitted according to a priority among the periodic UCIs for a plurality of DL CCs. In this case, the aforementioned various methods can be applied as a method of selecting one UCI for transmitting the periodic UCI. In addition, the DL CC for transmitting the aperiodic CQI can be excluded when determining a priority for transmitting the periodic UCI.

FIG. **22** shows the proposed UL control signal transmission method according to another embodiment of the present invention.

In step **S400**, a UE receives an aperiodic CQI request through at least one DL CC. In step **S410**, the UE determines a single UL CC to which the PUSCH is allocated. The aforementioned various methods may be applicable when determining the single UL CC. In step **S420**, the UE transmits an aperiodic CQI through the determined single UL CC.

Although a case in which the aperiodic CQI is transmitted for the plurality of DL CCs through the single UL CC is taken an example in the above description, the present invention is also equally applicable to a case in which the aperiodic CQI for the plurality of DL CCs is transmitted through a plurality of UL CCs. However, in this case, the aperiodic CQI and a periodic UCI can be transmitted separately through a UL CC, and a UL CC for transmitting the aperiodic CQI and a UL CC for transmitting the periodic UCI can be indicated respectively according to designated rules.

Meanwhile, when a request of the aperiodic CQI is received through at least one DL CC and transmission of a piggyback type of the periodic UCI is requested at the same time, there is a need to indicate a specific UL CC for transmitting a PUSCH for carrying the aperiodic CQI for the at least one DL CC and a PUSCH to which the periodic UCI is piggybacked. In general, if it is assumed that all UCIs are transmitted through one UL CC, transmission of the piggybacked periodic UCI has a priority not higher than that of the aperiodic CQI. Therefore, if transmission of the aperiodic CQI and transmission of the piggyback-type periodic UCI are required at the same time, transmission of the piggybacked periodic UCI can be dropped and the aperiodic CQI can be transmitted on a UL CC indicated by a UL grant including a request of the aperiodic CQI. If the request of the aperiodic CQI is received through one DL CC, it is simply not a request of transmission of the aperiodic CQI for one CC, and thus transmission of the aperiodic CQI for a plurality of CCs may be requested through one DL CC. In addition, if the request of the aperiodic CQI is received through the plurality of DL CCs, the aperiodic CQI can be transmitted by selecting any one UL CC among a plurality of UL CCs indicated by a plurality of UL grants including a request of the plurality of aperiodic CQIs. In this case, the aforementioned various

methods are applicable when selecting one UL CC. If there are sufficient PUSCH resources even after transmitting the aperiodic CQI, the periodic UCI can be transmitted through a UL CC indicated by a UL grant including a request of the aperiodic CQI. If the periodic UCI for the plurality of the UL CCs must be transmitted by piggybacking it, the plurality of piggybacked periodic UCIs can be transmitted through a UL CC indicated by a UL grant including a request of the aperiodic CQI according to a priority. In this case, a priority can be determined according to the aforementioned various methods.

Alternatively, if the request of the aperiodic CQI is received through at least one DL CC and the piggyback-type transmission of the periodic UCI is requested at the same time, a method of dropping transmission of the periodic UCI can be considered.

In addition, a UL CC for transmitting an aperiodic CQI can be determined by a UL grant without data to be scheduled. If there is no CIF in the UL grant, the aperiodic CQI can be transmitted through a UL CC having an SIB-2 linkage relation with a DL CC for transmitting the UL grant. If the CIF is present in the UL grant, the aperiodic CQI can be transmitted through the UL CC indicated by the CIF. Alternatively, if data is transmitted through a UL-SCH in at least one UL CC among configured UL CCs or activated UL CCs, it can be transmitted by piggybacking the aperiodic CQI on a PUSCH having a UL-SCH.

FIG. **23** is a block diagram showing wireless communication system to implement an embodiment of the present invention.

A BS **800** may include a processor **810**, a memory **820** and a radio frequency (RF) unit **830**. The processor **810** may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor **810**. The memory **820** is operatively coupled with the processor **810** and stores a variety of information to operate the processor **810**. The RF unit **830** is operatively coupled with the processor **810**, and transmits and/or receives a radio signal.

A UE **900** may include a processor **910**, a memory **920** and a RF unit **930**. The processor **910** may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of the radio interface protocol may be implemented in the processor **910**. The memory **920** is operatively coupled with the processor **910** and stores a variety of information to operate the processor **910**. The RF unit **930** is operatively coupled with the processor **910**, and transmits and/or receives a radio signal.

The processors **810**, **910** may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memories **820**, **920** may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The RF units **830**, **930** may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in memories **820**, **920** and executed by processors **810**, **910**. The memories **820**, **920** can be implemented within the processors **810**, **910** or external to the processors **810**, **910** in which case those can be communicatively coupled to the processors **810**, **910** via various means as is known in the art.

In view of the exemplary systems described herein, methodologies that may be implemented in accordance with the disclosed subject matter have been described with reference to several flow diagrams. While for purposed of simplicity, the methodologies are shown and described as a series of steps or blocks, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the steps or blocks, as some steps may occur in different orders or concurrently with other steps from what is depicted and described herein. Moreover, one skilled in the art would understand that the steps illustrated in the flow diagram are not exclusive and other steps may be included or one or more of the steps in the example flow diagram may be deleted without affecting the scope and spirit of the present disclosure.

What has been described above includes examples of the various aspects. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the various aspects, but one of ordinary skill in the art may recognize that many further combinations and permutations are possible. Accordingly, the subject specification is intended to embrace all such alternations, modifications and variations that fall within the spirit and scope of the appended claims.

What is claimed is:

1. A method of transmitting an uplink control signal in a carrier aggregation (CA) system including a plurality of uplink (UL) component carriers (CCs), the method performed by a user equipment and comprising:

determining whether a physical UL shared channel (PUSCH) is not scheduled in a primary CC (PCC) of the CA system;

when it is determined that the PUSCH is not scheduled in the PCC of the CA system, selecting one UL secondary CC (SCC) among a plurality of UL SCCs in which the PUSCH is scheduled, and

wherein the one UL SCC is selected according to a priority which is set by higher layer signaling; and

when it is determined that the PUSCH is not scheduled in the PCC of the CA system, piggybacking and transmitting a UL control information (UCI) of the PCC on the PUSCH of the selected UL SCC.

2. The method of claim **1**, wherein the one UL SCC selected according to the priority has a highest or lowest physical or logical index among the plurality of UL SCCs in which the PUSCH is scheduled.

3. The method of claim **1**, wherein the priority is set based on a cell index.

4. The method of claim **1**, wherein the priority is set based on a quality of service (QoS).

5. The method of claim **1**, wherein the selected UL SCC is a UL SCC scheduled in a downlink (DL) PCC.

6. The method of claim **1**, wherein the selected UL SCC is indicated by a UL grant or a downlink (DL) grant transmitted through a physical DL control channel (PDCCH).

7. The method of claim **6**, wherein the selected UL SCC is a UL SCC linked to a physical DL shared channel (PDSCH) to be scheduled by the DL grant or a UL SCC linked to a PDCCH for the PDSCH, or a UL SCC linked to a PUSCH to be scheduled by the UL grant or a UL SCC linked to a physical UL control channel (PUCCH) for the PUSCH.

8. The method of claim **6**, wherein the selected UL SCC is indicated by a carrier indication field (CIF) in the DL grant or the UL grant.

9. The method of claim **1**, wherein the UCI is a periodic UCI transmitted periodically.

10. The method of claim **1**, further comprising:

receiving a request of an aperiodic channel quality indicator (CQI) through at least one downlink (DL) CC.

11. The method of claim 10, wherein the aperiodic CQI is transmitted by being multiplexed with the UCI.

12. A user equipment in a carrier aggregation (CA) system including a plurality of uplink (UL) component carriers (CCs), the user equipment comprising:

a radio frequency (RF) unit configured to transmit or receive a radio signal; and

a processor coupled to the RF unit,

wherein the processor is configured to:

determine whether a physical UL shared channel (PUSCH) is not scheduled in a primary CC (PCC) of the CA system;

when it is determined that the PUSCH is not scheduled in the PCC of the CA system, select one UL secondary CC (SCC) among a plurality of UL SCCs in which the PUSCH is scheduled,

wherein the one UL SCC is selected according to a priority which is set by higher layer signaling; and

when it is determined that the PUSCH is not scheduled in the PCC of the CA system, piggyback and transmit a UL control information (UCI) of the PCC on the PUSCH of the selected UL SCC.

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